SRI LANKA ASSOCIATION FOR ARTIFICIAL INTELLIGENCE

International Conference on Emerging Trends in Artificial Intelligence
(ICE^{T}AI 2015)

29th December 2015
at
The Open University of Sri Lanka
Nawala

Sri Lanka Association for Artificial Intelligence – 2015

International Conference on Emerging Trends in Artificial Intelligence (ICE^{T}AI 2015)
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Sri Lanka

Editors:

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- Message from SLAAI President -

The International Conference on Emerging Trends in Artificial Intelligence (ICE^{T}AI), organized by the Sri Lanka Association for Artificial Intelligence of Sri Lanka (SLAAI), is the 12th annual gathering of researchers, academics, practitioners, enthusiasts and students who are interested in Artificial intelligence in Sri Lanka and the region. SLAAI was formerly established in year 2000 as a natural successor to the AI research group in Sri Lanka which functioned as a meeting place of AI researchers for over three years.

In today's global environment where Artificial Intelligence based systems have acquired a great importance in business, commerce, education, travel, health care, transport and many other areas, this conference is an important event. During the course of the year SLAAI has organized several workshops to create awareness of the theory and application of AI among students, organized meet ups to bring together AI enthusiast and many other activities to popularize AI in Sri Lanka.

This conference is the final event in the year where we provide a forum for all researchers and practitioners of AI to exchange ideas. For the conference, we have invited leaders of the Sri Lankan IT/BPO industry to deliver key note address and an invited speech on the importance and relevance of Artificial Intelligence in today's industrial systems. Seven other researchers will present the results of their research at the conference under the theme "Emerging Trends in Artificial Intelligence".

As president of SLAAI, I would like to thank all those who contributed to the success of ICE^{T}AI. This includes, but not limited to, the SLAAI Council who met many times to organize the conference, the panel of referees, the program committee, the organizing committee, volunteer sessions chairs, volunteer judges of the best paper presentation evaluation panel, those who organize logistics, the administration of the OUSL who wholeheartedly supported this conference, generous sponsors who supported the conference and many others who contributed to its success.

We should consider it our responsibility to create a better future for the next generation of students and researchers in academia and industry by supporting the creation of a Knowledge Society. I hope you will join with us in this endeavor.

Dr. Ajith P. Madurapperuma
President-SLAAI
27.12.2015

- Message from Chairperson Research Committee -

It is with great pleasure that I convey this message to the International Conference on Emerging Trends in AI (ICE^{T}AI) 2015 which is organized by the Sri Lanka Association for Artificial Intelligence (SLAAI). ICE^{T}AI 2015 is the successor of the Annual sessions of SLAAI. In the past, there have been 11 annual sessions continuously. Members of SLAAI have taken a lead role in introducing, facilitating and promoting Artificial Intelligence education and research in Sri Lanka over the past 12 years. In doing so annual sessions has been a corner stone as well as a looking forward event by the AI community.

I am very happy to note that this year SLAAI has taken a one step forward from annual sessions to a conference which will add more rigor to the AI community. The aim of this conference is to give a platform for undergraduate, postgraduate as well as researchers to present their work in a public forum because SLAAI is an independent body that comprise of academics, researchers, students and general public who are interested in AI. In addition ICE^{T}AI will provide a platform to all these researches to present their work to the Industry, hence taking some of the work beyond their academic level to commercial level.

In making ICE^{T}AI 2015 a success, the lead role is played by the authors of the papers and the review panels. The review panels for ICE^{T}AI 2015 were from academia as well as from industry personals. I would like to appreciate the great work done by local as well as foreign reviewers in the double blind reviewing process. I am sure that the comments received by the authors after the reviewing process will enable them to identify new directions with innovative developments to take the work to a higher level of achievement.

On behalf of the research committee I would like to pay my gratitude to sponsors of the event for making the ICE^{T}AI 2015 a reality. I would also like to thank the Vice Chancellor of the Open University, the Dean of the Faculty of Engineering Technology and the staff of the Department of Electrical and Computer Engineering for their sustained support in making ICE^{T}AI 2015 a success. The members of the council have been the pillars of the success story of ICE^{T}AI 2015.

Dr. Menaka Ranasinghe
Chairperson
Research Committee- SLAAI
22.12.2015

-Keynote Address-

The Impact of AI within Global Industry

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Abstract:

Starting life as mathematical models in mathematics departments, AI technology was later adopted by Computer Science academics as a primary research area. There have been huge advances in AI technology and models over the past 30 years. The most significant development, however, has been the adoption of AI in traditional industry. AI is presently one of the hottest buzz-words in industry and billions of Dollars are available to fund industry related AI applications. AI systems are now used across most industries.

Traditional industry and industrial processes and applications are based on proven procedures and decision making paradigms. What data is shown to the system and what is done with this information is predetermined by an expert, who assists a process engineer or a software developer to facilitate the processes. AI based systems differ from these through the use of a logical inference or learning module. This AI module needs to be initially trained using a set of data and related outcomes or actions, known as training data. Once training has been completed and validated, it can be used to infer outcomes or actions based on input data. The primary difference with traditional systems is the fact that a engineer does not explicitly define all possible inputs and outcomes, and instead, the training process facilitates the creation of an automated decision making process based on the training data. The capabilities of such a system would typically far exceed the capabilities of a traditional system through the ability to infer outcomes for input data which were not present in the initial training data set. A inference module can usually fill in all the gaps of a training data set, and thereby theoretically handle all permutations of input information. The ability to automate the entire training process also enables the engineer to use big data sets for training, thereby increasing the probability of maintaining high rates of decision precision.

AI systems are now utilized across most industries. Finance is an early adopter of AI based systems and many companies now use AI based modules to advise investors, create portfolios and make actual transactions and trades. The wealth of information available through the past few decades makes this an evolving process with better systems being created each day with better data. Machines are now not only number crunching, but actually making decisions and executing them. Similarly, medicine, law, gaming, simulation, manufacturing, engineering are but a few examples of the industries which have benefitted greatly through the use of AI.

With this proliferation of interest in AI based modules for process improvement, the demand for engineers who understand the math and algorithms used in AI are increasing. The

bottleneck for industry is primarily with ideas not being generated on how AI can be used to improve how they do things. This can be addressed by improving education in the possibilities of AI within industry. One of the best ways to achieve this is through improving awareness and knowledge of these techniques among university IT students – the primary source of technical talent used by local industry.

Dr. Romesh Ranawana DPhil (Oxon)
Co-Founder and Managing Director of SimCentric Technologies

Romesh combines proved leadership skills in Computer based research and development with a strong academic background. He is a Clarendon Scholar with a Doctorate in Artificial Intelligence from Oxford University and a 1st Class Honours degree and University Scholarship from the University of Peradeniya. Romesh has over 20 international peer-reviewed publications in the field of Artificial Intelligence and Machine learning technologies. His most recent commercial endeavour was as the chief architect and R&D lead of the DrugFinder system developed by InhibOx Ltd., which is an Oxford University owned company that specialises in the development of new Cancer drugs through computer based modelling. Romesh is presently the Managing Director and Chief Technical Officer at SimCentric Technologies. SimCentric Technologies develops simulation based training and training support products for a large global clientele. Romesh has lead development of all SimCentric development efforts and wrote the first versions of many of SimCentric's commercial offerings.

-Invited Talk-

AI for Masses - What's in It for Us

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Abstract:

Artificial Intelligence and machine learning has been used in several industries with limited amounts of public exposure for decades. The new millennium saw an upsurge in the applications of Artificial Intelligence in the public-facing consumer applications. The availability of tools and other means for using AI in research was also increased at the same time. Many open source frameworks for Machine Learning, Natural Language Processing, Ontologies, Deep Learning, and Information Extraction that are freely available today make the Rapid Prototyping for AI-based applications easy and affordable. With all these, Artificial Intelligence has again become a buzzword which is exposed not only to a select community of specialized research but for a wide audience of science writers and software developers.

Is this trend is yet another hype wave as it has been few decades ago, or is it something based more on reality and facts? There are substantial changes in the field of computing that made the research and applications more sustainable in the real world. In addition to the advances in the field, the future holds more promising applications with the advent of peripheral developments such as Internet of Things.

With the barrier to entry lowered, developing countries such as Sri Lanka has something promising in the new developments. Already the industry is starting to catch up with the world. However, there is much that is needed to be done, and not only the investors and research leaders, but also the work force and educators will have to adapt for the new market reality if we are to reap the advantages of the changing landscape of AI.

Dr. Upali Kohomban PhD (NUS)
Head/Research and Development in CodeGen International (Pvt) Ltd.
Upali earned his bachelors in Computer Science and Engineering with a First Class Honours from University of Moratuwa, and his PhD in Computer Science from National University of Singapore. In addition to his experience in the Sri Lankan Software Industry, he has worked for the National University of Singapore and Institute for Inforcomm Research in Research and Development projects for Natural Language Information Extraction in Biomedical and Defense fields. He has also served as a visiting lecturer and academic supervisor at University of Moratuwa and University of Colombo. Upali currently heads the Research and Development in CodeGen International, and is engaged in a number of AI-related research areas, including Data Mining, Natural Language Search, Information Extraction, Semantics, and Ontologies.

Towards Intelligent Sensor Fusion based Visually Impaired Navigation: An Assistive Technology Framework

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Abstract

This paper presents the development of an electronic navigation framework for blind and visually impaired persons. This proposed approach aims to intelligently fuse the surrounding information sensed via ultrasonic sensors and vision sensors. The intelligent component of the prototype developed would serve in several facets including object recognition and computational performance optimization within the embedded system software. The prototype developed for field testing in indoor as well as outdoor environments would be used as assistive technology for visually impaired. The wearable device developed would provide the feedback via tactile cues. The current status of the research and the future developments are presented in this work.

1. Introduction

There are about 285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 have low vision that could benefit from some form of aid to help them in their daily lives[1].

Visually impaired persons face constraints in independent mobility and navigation, especially in unknown or dynamic environments. Blind navigation is a cognitively demanding task since blind person does not have access to contextual information, spatial orientation and it requires moment-to-moment problem solving. Researchers attempt to develop humanitarian technology based navigation systems to aid the visually impaired. These navigational aids consist of several types of sensors such as infra-red sensors, ultrasonic sonar sensors, vision sensor, inertial sensors, etc.

A fusion of different sensors which allows the extraction of information which cannot be acquired by a single sensor. Different type of sensor works differently and they have their own strengths and weaknesses. Since one sensor cannot provide all the necessary information, sensor fusion intelligently combines the strength of different sensors to overcome the drawbacks of the other[2, 11].

In this work, an electronic travel aid to navigate visually impaired persons had been proposed. The long-term goal of this resaerch is to create a portable, self-contained navigation aid which makes optimum use of all the sensors for smooth and continuous navigation of visually impaired individuals to travel through familiar and unfamiliar environments. Although sensor fusion combines different sensors and multiple technologies to gain successful navigation over a wide range of environmental conditions, it will be a great challenge [12].

2. Related work

Ultrasonic sensors are designed to generate high frequency sound waves and receive the echo reflected by the target. These are common for target detection and tracking. There are some constraints which limit the accuracy of detecting obstacles by ultrasonic sensors. Sonar device is not suitable to be used by multiple users who travel through the same environment because sonar reflections may interfere with each device's sensor waves[3]. The variance of the temperature, humidity and pressure will affect the response of the sensor. The wide sonar beam causes a poor directional resolution and are often difficult to interpret. Also smooth surfaces

at oblique incidence do not produce detectable echoes. An ultrasonic sensor has a limited sensing distance, when compared to most of other sensors. Numerous research have been reported in literature where they have used sonar based obstacle detection [5, 6, 7].

Vision sensors are widely used for detecting the presence or absences of objects or identifying features of detected objects. Compared to other sensory modalities, computer vision can also provide a very rich information of the environment. The major drawback of using vision sensor is, it requires high computer processing power. Some special situations like detection of glass surfaces via cameras are problematic. Also background illumination affects very much on obstacle detection because vision based obstacle detection approaches work well only when there is a good lighting condition. Vision based obstacle detection in visually impaired navigation is also a common research approach [8, 9, 10]

Fusion of these two types of sensors has been considered as an improvement since both vision base and ultrasonic sensor base obstacle detection have their own weaknesses. Sensor fusion is used in many ares such as robotics, GPS and inertial sensor based navigation, Unmanned Aerial Vehicle and etc.

2.1 Robot Navigation and Sensor Fusion

Robotics is a leading branch of engineering, which demands knowledge of hardware, sensors, actuators and programming. For an autonomous mobile robot, sensor fusion is important to perceive its environment. An autonomous robot moves unsupervised. It obtains information of surrounding environments using its sensors and decides its course of action based on that[2].

Use of sensor fusion in robot navigation is an emerging trend.

A quadruped walking robot has been used as a platform to test and demonstrate the development and implementation of a behavior selection based obstacle avoidance algorithm. The obstacle is roughly measured by processing the image acquired through the USB camera, and the ultrasonic sensors are used to complement the visual information in relation to obstacle and to perform the selection of the suitable actions at the right time [4]. Other research had used multiple ultrasonic sensors for intensive observation and image sensor for wide-angle observation in a robot sensing project. Here two kinds of fusion has been implemented; one fuse multiple ultrasonic sensor data and other fuse the two types of sensor data [5]. One of the common approaches of integrated vision-based process for mobile robots that is capable of simultaneously navigating and avoiding stationary obstacles using monocular camera images and moving obstacles are detected with ultrasonic sensors [2]. Also building a map for a laboratory robot by fusing range readings from a sonar array with landmarks extracted from stereo vision images using the SIFT algorithm. [6]. Fusion of the sonar measurements and an updated odometric measurement by using a decentralized information filter to produce optimal estimations of the robot states, thus minimizing the uncertainty in the sensor measurements[7]

2.2 Visually impaired Navigation and Sensor Fusion

Number of attempts on fusion of different sensors in blind navigation can be found in the literature. Fusion of GPS and vision based positioning was used in object-localization and user-positioning [8]. Another research which uses sonar for detecting large and high obstacles, and vision system is to detect small obstacles. One has been stated that the ideal solution is likely to be the use of both a visual, and a non-visual sensor as an input to the Kalman Filter, which should make available the benefits of both[9].

The purpose of this research is to fuse the signals of vision and ultrasonic sensors for obstacle detection in navigation of visually impaired and blind persons.

3. Architecture

Basic design approach can be divide in to three parts. The first part relates to sense the environment using ultrasonic and vision sensors and preprocess them. The next is the

fusion module which fuse the signals of both sensors. Finally output of the fusion module is filtered and send to appropriate feedback modules.

Current implementation will be based on several assumptions. Visually impaired navigtor need to detect and avoid both stationary and moving obstacles. Vision sensor is used for detection of stationary obstacle and ultrasonic sensors (ultrasonic sensors have no intrinsic way of distinguishing between moving and stationary obstacles) are used to detect close range moving obstacles [5, 8]. Therefore Detection of moving objects is much more complex than detection of stationary objects. Since the main target of the proposed research is to benchmark the accuracy of sensor fusion with respect to individual sensor modalities. Therefore detection has only confined to identification of stationary obstacles. Proposed electronic travel aid will be initially evaluated in a less obstructive indoor environment. Consider only the local navigation: the surrounding of the visually impaired person is unknown, and sensors are used to detect the obstacles and avoid collision (No specific goal and path is defined)[8]. Sonar sensor distance measurement is calculated under room temperature. It is wise not to be used this hybrid module by more than one user simultaneously under a maximum scanning range of sonar sensors.

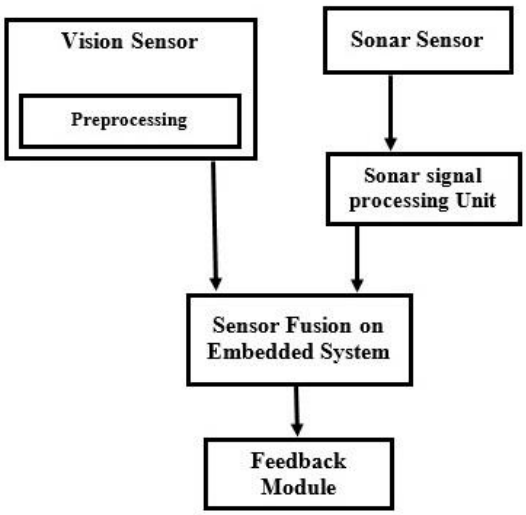

Figure 1: Schematic Diagram of proposed system

3.1 Sub components of the system

Sonar Sensor: Sonar sensor continuously transmit the waves which have with high frequency. When object comes in the path of signal then it will reflected by object and received at sensor receiver. Then signal processing unit calculates the distances based on the time spent waiting for the wave to come back. Then the resulting data is sent back to the sensor fusion module.

Vision Sensor: Images captured by the vision sensor are preprocessed by processing system unit inside the vision sensor. So the vision sensor provides higher level semantic output potentially to the fusion module without overloading its processing unit by sending all of the image data.

Sensor Fusion on Embedded System: This approach combines sensor data from vision and sonar to provide a higher order of functionality. Hence additional processing capability is required due to the increasing complexity of sensor fusion algorithms. Therefore fusion of the sensor data is carried out on a separate processing device.

This research focus on wearable electronic navigation system which should be an efficient travel aid for the visually impaired and blind persons. Light weight, faster response, low power consumption and less hardware are some of the critical factors to be considered when designing wearable electronics. In order to fulfill above factors embedded system is selected as the fusion module instead of PC. Embedded system is dedicated to one specific task which requires less computing power and hardware to perform that dedicated task while PC is designed to run many different types of software and to connect many different external devices. Then preprocessed sonar and vision data are fused at this embedded device by applying fusion techniques.

The viability of the fusion of two sensor data in the sonar signal processing unit itself will be further investigated in future.

Feedback Module: Lastly filter the output signal which is received by sensor fusion module and send that commands to appropriate feedback modules.

The ultrasonic range finder will be used as a sonar sensor for measuring distances. Input sonar signals are processed by microcontroller board. Vision sensor processes the images from the image processor which is built within the vision sensor itself and sends the preprocessed information to embedded system based sensor fusion module. Then fusion module further process-the ultrasonic and vision data.

There are a number of fusion methods available. Probabilistic data fusion method is common which is generally based on Bayes' rule for combining prior and observation information. Theory of evidence, interval methods are some of alternatives to probabilistic methods in sensor data fusion. [11].

The final output of the sensor fusion module is filtered and check whether an obstacle is located in which direction of the user and send commands to relevant vibration motors to generate appropriate levels of vibration.

A pilot study will be conducted prior to the evaluations in order to predict an appropriate sample size and check the feasibility of other evaluation parameters. The evaluation process will continue in an environment which was not seen by the participants before. These tests will be carried out using totally blind and blind folded users. Training on the proposed navigation aid will be given to all participants to familiarize with the system before the evaluation process.

Separate tests will be carried on obstacle detection in visually impaired navigation using sonar sensor based method and vision based method. And the results of these two tests will be compared with the test results of fusion of vision and ultrasonic based obstacle detection approach.

Test results will evaluate based on the user reactions to different obstacles, time taken by each user to complete the navigation process, training sessions that he/ she participate prior to the evaluations and etc.

4. Conclusion and Future Work

This research will address following issues related to sensor fusion based obstacle detection in visually impaired navigation.

Identify the relevant fusion framework to detect obstacles via vision based and the sonar based approaches. Select appropriate multisensory data fusion techniques and fusion algorithms. Optimize the obstacle detection by balancing the load of the two channels (vision based and sonar based approaches). Benchmark the self-adaptive nature of hybrid approach and evaluate it against the vision only and sonar only obstacle detection methods.

References

[1] S. L. Gur, S. Sil, P. Chamde, U. Gajiwala, J. Zaveri, S. Samuel, S. H. Tumbe, and S. Ramalingam, "Guidelines for Comprehensive Management ofLow Vision in India A vision2020: The Right to Sight- India Publication," 2012.

[2] M. Hons, "Obstacle Detection and Size Measurement for Autonomous Mobile Robot using Sensor Fusion," vol. 66, no. 9, pp. 1–105, 2010.

[3] Y. M. K. Priyadarshana, G.D.S.P. Wimalaratne, "Sensing Environment Through Mobile: A Personalized Wearable Obstacle Detection System For Visually Impaired People" pp. 1–8, 2014.

[4] K. Izumi, M. K. Habib, K. Watanabe, and R. Sato, "Behavior selection based navigation and obstacle avoidance approach using visual and ultrasonic sensory information for quadruped robots," *Int. J. Adv. Robot. Syst.*, vol. 5, no. 4, pp. 379–388, 2008.

[5] K. Umeda, J. Ota, and H. Kimura, "Fusion of Multiple Ultrasonic Sensor Data and Image Data for Measuring an Object ' s Motion," vol. 17, no. 1, pp. 1–2, 2005.

[6] A. C. H. Avez and H. Raposo, "Robot Path Planning Using SIFT and Sonar Sensor Fusion ′," pp. 251–256, 2007.

[7] R. Carelli and E. O. Freire, "Corridor navigation and wall-following stable control for sonar-based mobile robots," *Rob. Auton. Syst.*, vol. 45, no. 3–4, pp. 235–247, 2003.

[8] A. Brilhault, S. Kammoun, O. Gutierrez, P. Truillet, and C. Jouffrais, "Fusion of Artificial Vision and GPS to Improve Blind Pedestrian Positioning," *Int. Conf. New Technol. Mobil. Secur. (NTMS 2011)*, no. August 2015, pp. 1–5, 2011.

[9] N. Molton, S. Se, J. M. Brady, D. Lee, and P. Probert, "A stereo vision-based aid for the visually impaired," *Image Vis. Comput.*, vol. 16, no. 4, pp. 251–263, 1998.

[10] J. a. Hesch and S. I. Roumeliotis, "Design and Analysis of a Portable Indoor Localization Aid for the Visually Impaired," *Int. J. Rob. Res.*, vol. 29, no. 11, pp. 1400–1415, 2010.

[11] H. Durrant-whyte and T. C. Henderson, "Multisensor Data Fusion," *Robotics*, pp. 585–610, 2008.

[12] S. Brassai, L. Bako, and L. Losonczi, "Assistive Technologies for Visually Impaired People," *Acta Univ. Sapientiae ...*, vol. 3, pp. 39–50, 2011.

Multi-Agent Based Train Controlling System

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Abstract

Application of agent based system is very important in fast moving world with modern technologies in order to deliver maximum productivity using minimum resources. In the railway domain, this will account for reducing unnecessary train traffic on rail network and reduces operational overhead. This research paper discusses how this technology has been applied for the benefit of Sri-Lanka Railways.

1. Introduction

Many developed countries in the world now pay their attention for implementation of cost effective transportation systems. Main factors are being considered to reduce power consumptions, environmental pollutions with minimum maintenance cost as well as to provide maximum productivity using minimum resources. Another critical problem is rapid proliferation of number of road vehicles that causes big issues to the natural environment [1]. Creation of heavy traffic jams are inevitably affected in the area of the most populated commercial cities.

This has also become a common problem to Sri Lanka. Number of vehicles daily adding to the road traffic is getting doubled comparatively to past years [2]. This is one of the hammering problems faced by daily travelers due to heavy traffic jams. Therefore the travelers and the governments strive hard to find alternative solutions to alleviate this problem [3]. However, many developed countries are now investing more money for enhancing of the railway infrastructure because they have identified railway transportation as the most efficient and the economical transportation media. In Sri Lanka number of rail commuters is dramatically increased during past years. In order to cater increasing customer demand railway authorities have to maximize its train capacity and productivity with required infrastructures. This leads for implementation of proper and efficient train controlling systems. This is a very crucial point that Sri Lanka Railways has been overlooked for several years. In SLR, management has been struggling since many years to operate trains on scheduled times without any delay and maximize track capacity. However application of manual systems to handle increasing number of train traffic has led the train operation into chaotic situation with creation of more and more complexities. Therefore automation has become the vital solution in order to alleviate above problems in domain of railway scheduling and controlling. In the current scenario there is no any data communication system between train drivers and also with train controllers. Train controllers cannot detect individual real time positions of each train without consulting the corresponding station masters. In Sri Lanka Railway (SLR) the critical decisions are made on a non-systematic manner and leads to conflicts.

Considering over last decades railway industry has been developed in many countries and automated systems are successfully being implemented in some other countries. Among high technical areas in engineering, like mechatronics and electronics, computer aided controlling systems, embedded systems, wireless sensor networks and data communication technologies are successfully integrated into the train controlling and optimization systems. Considering, railway scenario is not centralized system. It is a distributed and scattered system. Therefore multi agent based communication and

controlling system is capable in controlling train traffic on rail network [4,] [5]. This system is completely distributed and adaptable architecture for railway traffic control and pave the way for establishment of communication based train controlling [6] [7].

This paper is organized into five main sections in order to discuss how system has applied. In section two it discuss the system architecture with hardware components and assumptions. Third section explain methodology and fourth section explain how system works and algorithms applied in the railway scenario. Fifth section will discuss results and drawbacks and further improvement.

2. System Architecture

Basically, our proposed system encompasses with three modules with a learning layer. The three modules are train module, control module and station module as in [8]. Train module interacts with mobile agents. Each train running on rail network is considered as mobile agent and it always communicate with train module. Control module interacts with zonal control agents which are responsible for controlling trains within zonal areas. Station module interact with station agents and altogether interact to make decisions regarding train controlling assisted with train drivers, train controllers and with station masters.

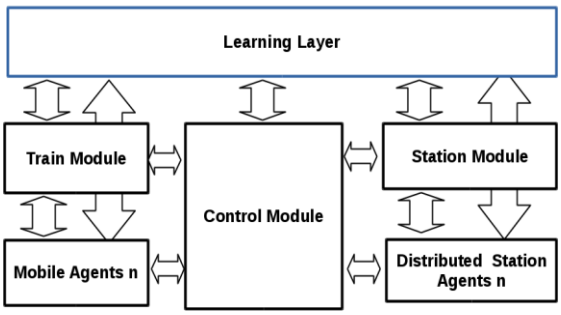

Figure 1: System Architecture

Train module, control module and station module can altogether consider as control layer. This is responsible for establishing security between trains, controlling its speeds, supporting for train crossing arrangements, etc. Responsibility of learning layer is inferencing rules needed for safe running of trains. Its maximize productivity by minimizing waiting time. Learning layer analyze the data accumulated by the controlling layer. This layer pass infer rules to controlling layer like "at time T_1 train t_1 at point $P_1 = (x_1, y_1)$ destination D_1 conflict after time T_i in track length L_i with another train t_2 at point $P_2 = (x_2, y_2)$ destination D_2" This type of rules are transmitted to the control layer when similar type of traffic situation has detected. Confliction is two trains try to enter to a section in same time.

Modules

In this section explain brief introduction of each module and their roles with in the system.

Train module

This module interacts with each running trains and gather important running data. It collects velocity of each trains, GPS location, time, and destination, train ID, *section in* and *section out* times, etc. Each train running on network is considered as mobile agent under this module. Each train considered as a mobile agent, based on wireless sensor network (WSN) integrated with Internet Protocol (IP) capability, implemented in driver's cab. This provides an interface to communicate with train driver. Once command is given, it start to send data packets in every ten seconds to the central server. These data packets include Global Positioning System (GPS) data, velocity, train Id and XYZ coordination. Main consideration of this research is to implement and utilize low cost devices in order to provide very efficient and productive agent based distributed train controlling system. This device also facilitate voice communication over wireless network.

GPS is very important for navigation class of problems and initially began as US project in 1973. Now it's widely use in everywhere in the world for detection position, time and speed. In this research GPS technology used to calculate position, speed and time of running trains. Device gather this data and send to the central server using General Packet Radio Service (GPRS) technology over Global System for Mobile (GSM) communication.

GPRS technology is a value added service that facilitate to send and receive data transfer across a mobile telephone network. Maximum speed of data transfer up to 171.2 kilobits per

second (kbps) are achievable with GPRS. This is enough to apply moving train of 60 - 90 kmph and it will create negotiable delay of calculating real time speed. An example of information send in data packets from different trains are shown in Fig. 2.

```
                                                  | 17:58:20  | 2014-05-13 |        34.2 |  173.9 | D
1780701 |    5.95188825 |    80.54415568 | 8056
                                                  | 17:58:22  | 2014-05-13 |         4.5 |   95.3 | D
1780702 |    6.89259928 |    79.85335114 | 8764
                                                  | 17:58:09  | 2014-05-13 |         6.3 |  183.9 | D
1780703 |    6.58384967 |    79.95892644 | 8062
                                                  | 17:58:23  | 2014-05-13 |        32.4 |  174.1 | D
1780704 |    5.95188151 |    80.54418855 | 8056
                                                  | 17:58:24  | 2014-05-13 |         3.6 |   88.5 | D
1780705 |    6.82935154 |    79.86298382 | 8051
                                                  | 17:58:24  | 2014-05-13 |          45 |  341.9 | D
1780706 |    6.58363446 |    79.95896547 | 8062
```

Figure 2: Structure of Data Packet send by Mobile Agent

Device implemented on train driver's desk is shown in Fig. 3.

Figure 3: Mobile Agent Implemented on driver's desk

Station Module

Station module encompasses with station agents. This is responsible for allocation of available station platforms, managing dwelling times and routing. Train position and approaching details are shown in Fig. 4.

1) ***Control Module***

This module encompasses with other zonal control centers. Control centers analyze data gathered from mobile agents and station agents. Based on analysis, control module generate decisions regarding running trains with the help of inferring rules of learning module. Main roles of control module is establishment of security of running trains by avoiding conflictions. This is an integrated process of all three main modules with human assistant whenever possible.

Figure 4: Train indicated by Arrow on map

Train indicated by arrow

Control module assign train speeds, crossings and arrange routings, etc. For this role control module communicate with station module and train module. However, control module can directly communicate with mobile agents and station agents. Control module consist with following components.

3. Methodology

The methodology stands on three important assumptions.

Assumptions

Based on below assumptions rest of this paper explains how the proposed system works. This research is conducted in real environment, initially utilizing of fifteen number of trains in order to cover thirty journeys. Southern coastal railway line is selected and applied on single line railway track from Aluthgama to Matara.

01) Assumption 1

First assumption is to consider rail network as an undirected graph. Each station is a node of a graph and line between nodes is an edge.

02) Assumption 2

Wireless signal strength is uniformly distributed all over defined rail network.

03) Assumption 3

Number of sattelites (n) in line of sight at any time is
n >= 4. Therefore, speed calculation delay can be negotialble.

Methodology

Once train approached to the start point of its journey, train drivers are needed to login to the system. Then mobile agent begin to track, positions of trains every ten seconds with their velocities.

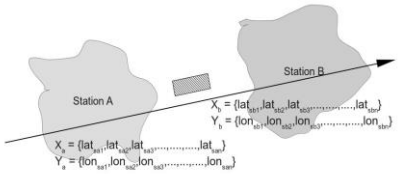

Figure 6: Rectangle Bound Theory

After receiving relevant GPS data control module analyze them to identify train locations. For this purpose, system use rectangle bound principal [9] [10] [11]. It compare longitudes and latitudes passes by the mobile agent with known set of longitudes and latitudes within particular area as in Fig 6.

1) Mathamatical Model

X_{trn} ' = {x : x is latitude send by device n in train id n}
Y_{trn}' = {y: y is longitude send by device n in train id n}

$lat_{tn} \in R$ and $lon_{tn} \in R$ S_n = n stations

lat^{tn}_{dn} = latitude sent by train n and device n in t_n time slot
lon^{tn}_{dn} = longitude sent by train n and device n in t_n timeslot

X_{trn} ' = {lat^{tn}_{dn1} , lat^{tn}_{dn2} , lat^{tn}_{dn3} , …,...,...,....,lat^{tn}_{dnn} }
Y_{trn} ' = {lon^{tn}_{dn1} , lon^{tn}_{dn2} , lon^{tn}_{dn3} ,...,...,...,....,lon^{tn}_{dnn} }

X = {a: a is a latitude of station A}

Y = {b: b is a longitude of station A}

According to RBP following algorithms used to identify (Algorithm A) station node and (Algorithm B) edges.

2) Alogorithm A

```
Do
        if (x '⊂Xa  && y '⊂Ya ) {
                position is station A;
      } else if (x '⊂Xb && y '⊂Yb  ){
                position is station B;
        } else {
                position is not station A or B;
        }
  End
```

3) Alogorithm B

```
  Do
        if(x' <= Xmax) && (x' >= Xmin)

                + && (y' <= Ymax) && (y'
>=Ymin) {

                        train is within the Sn limit;
          } else {

                        train is out of the Sn limit;
        }
    End
```

Identified details by control module is sent to acknowledge general public and other users. An example of display is shown in Fig 7.

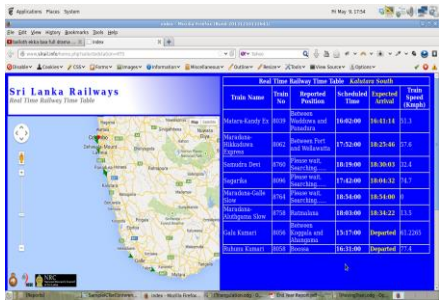

Figure 7: Display of Train Positions

Thus collected and generated data applies to optimization engine of the control module. Inside OE it search for occupation of each train and monitor their velocities. This also verify dwelling times of each edges and nodes. When a train enter to a particular station (node) mobile agent of that train sends *line in* time to the control module and when it exit the same

node it sends *line out* time. This is shown in Fig. 8.

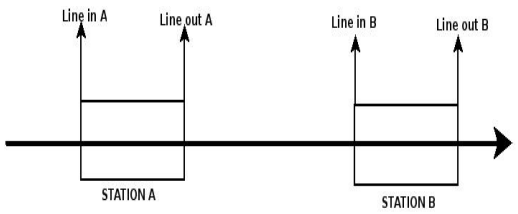

Figure 8: Display of Train Positions

If a particular train consume more time to travel in a particular edge than defined time slot OE monitor and send notification to next train which is waiting to enter to occupied edge. Every time OE perform time table rescheduling task and notify train controller and driver with suitable suggestions. Next section will explain how to perform this task.

4. Algorithm

Once a train driver login with the system, then it identify that train with its specific train ID. Therefore, by this way system possess essential data set of each running train in rail network. Optimization of trains performances by applying Ant Colony Algorithm as follows. It find out minimum travel time and dwell time for each train imitating ant's behavior of ant colony.

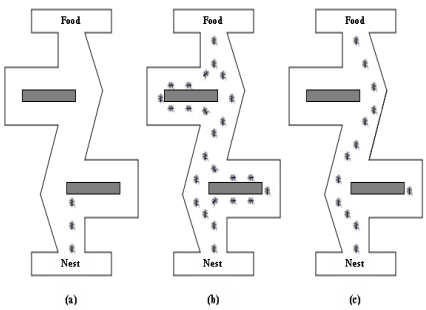

Figure 9: Display of Ant Colony Algorithm

1) Ant Colony Algorithm

Ant Colony Algorithm is a heuristic algorithm to solve NP hard problems and that is an imitation of ant's behavior of finding the shortest path between ant colony and food source. This concept is shown in Fig 9. Ant's use pheromones which are chemical substances can sense by other ant's in order to find out the shortest path as in [12]. All pheromones are updated regularly and those are not updated will become inactive due to evaporation of chemical substance. Pheromones are storage mechanism that pass over information regarding path to food source and let it next ant to read. In railway scenario this research applies algorithm in order to optimize rail traffic [13]. Each train consider as an ant, and update pheromones while its journey. The probability $P_{ij}^s(t)$ of ant s^{th} travelling from i^{th} position to the next position j^{th} is given by

$$P^s_{ij}(t) = \frac{[\tau^{\alpha}_{ij}][\eta^{\beta}_{ij}]}{\sum_{l \in N^s_i} [\tau^{\alpha}_{il}][\eta^{\beta}_{il}]} \quad \text{----------(1)}$$

τ_{ij} represent the pheromone concentration with the edge.

η_{ij} represent the heuristic information (obtained based on experience)

$\eta_{ij} = 1/ d_{ij}$ where d_{ij} is the distance between two positions i and j

If $\alpha = 0$ probability is based purely on heuristics and positions close to each other are chosen. This situation behaves very similar to greedy algorithm.

If $\beta = 0$ probability based on pheromone concentration. Sometimes can lead to localised search space.

Thus every relevant pheromones are updated by each ant that travel through each positions according to ant's behaviour and algorithm.

$$\tau_{ij}(t+1) = (1-\rho).\ \tau_{ij}(t) + \sum_{k=1}^{m} \Delta\tau_{ij}\ \forall(i, j) \text{---(2)}$$

In above formula ρ represents the evaporation rate to avoid accumulation of the pheromones

$$\Delta\tau_{ij}^{S}(t) = \begin{cases} \frac{1}{L_S} \\ 0 \end{cases} \quad \text{---------- (3)}$$

Where L_S is the total length of the ant's 'S' tour.

In railway scenario there are several pheromones. One is local pheromone which is read locally by trains running on particular line and other is global pheromone. Global pheromones are read by trains running on other lines. Third type of pheromone is control pheromones updated by train controllers. Train controllers can change train behaviour by updating this control pheromones. Pseudo code of updating pheromone by ants as follows.

```
Start (Ant Colony System)

    Set pheromones to initial state (assign initial values)

    While (not satisfy the condition for termination) do
            Start to verify by each ants

                For i = 1 to n do (#ants)

                    For k = 1 to m do (#nodes)

                        Apply State Transition Rule

                        Update pheromones (Local)

                    End for
                End for

            Update pheromones (Global)

        End While
    End (Ant Colony System)
```

Each trains before entering to station i (node) or depart from a station to an edge e_{ij} those become to a transition state. In this state before move, each train read relevant pheromones and take decision regarding next move according to transition rules. Thus mobile agents (ants), station agents and control agents pass real time information to each other via WSN.

5. Implementation

This system encompassed with following units. Mobile agent is main unit fixed in each Diesel Multiple Units (DMUs) or locomotives. Main role of this mobile agent is to collect GPS data and pass them to zonal agent within regular time intervals. Usually six data packets per sixty seconds of time. Except main role, mobile agent keep continuous interaction with train drivers by providing interface for communication, message passing with other agents. This mobile agent is encompasses with Quad core 1.4 GHz Cortex-A9 CPU with Mali-400MP4 GPU. It is also equipped with 1GB RAM and Android 4.3 (Jelly Bean) OS. Mobile agent need high processing power to do calculations efficiently. It has to collect data and send them via GPRS, HSPA+, 4G LTE or using whatever technology with train speed. Device need to keep data in a queue and send them gradually to the central server where in the areas distributed with low signal strength. Therefore it need sufficient capacity of RAM.

Second unit is station agent. This is normal computer with low processing power. Its main role is providing interface to station masters for communication and data inputs.

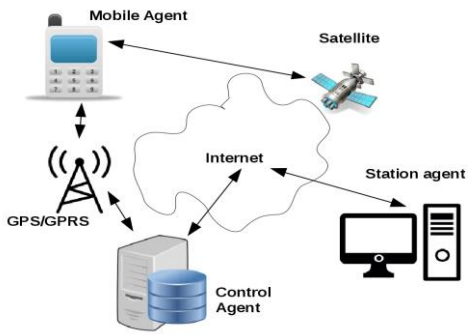

Figure 5: Basic System Architecture

Main processing units are zonal agents and central agent (control agent) of this system. All computations are taking place there and need high processing power. Control agent encompasses with Intel Core i3 2.7GHz processor, 8GB RAM, MySQL 5.5 database server, Red Hat Linux Server, JEE, Struts2 and Spring 3 MVC frameworks, Hibernate 3. Tomcat 6. Application work in Apache2 and Tomcat 6 integrated server.

Optimization of train traffic is NP-hard problem and it need application of heuristic algorithms in order to get feasible solutions for

time table problem. Main goal of this research is optimization of train traffic applying multi-agent based system. According to ant colony algorithm iterations are increased with the increasing number of mobile agents and station agents. In order to perform calculations efficiently high processing power is needed.

6. Results and Discussion

This research was applied to fifteen number of trains in southern coastal line. Results taken from train numbers 8059 (Ruhunu kumari) running from Matara to Colombo, 8057 (Galu kumari) running from Matara to Colombo and 8040 (Kandy Matara Express) are shown in following tables. In tables stations are mentioned as Nodes. (Node 20 is Matara and Node 0 is Kalutara South).

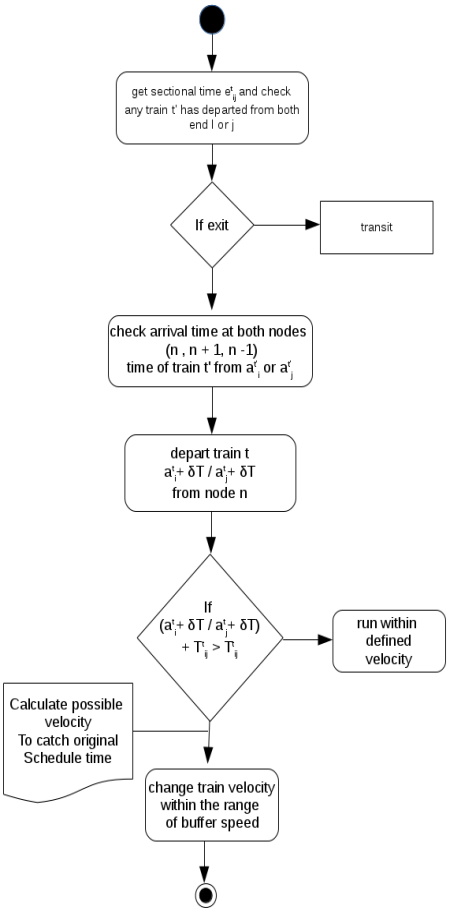

Figure 10. The process of transition

There are three main columns and under schedule mention arrival and departure times at each node according to schedule time table. Real arrival time and departure times are under real main column and optimized arrival and departure times at each nodes after applying Ant Colony Algorithm are under ACO. In this table arrival time 0.00 means that train will not stop at that node.

Node number	Schedule		Real		ACO	
	Arr	Dep	Arr	Dep	Arr	Dep
Node 20	0.00	6.05	0.00	6.07	0.00	6.07
Node 19	6.11	6.11	6.16	6.16	6.12	6.12
Node 18	6.18	6.19	6.24	6.27	6.22	6.23
Node 17	6.26	6.27	6.32	6.35	6.32	6.33
Node 16	6.32	6.32	6.40	6.40	6.39	6.39
Node 15	6.36	6.36	6.46	6.46	6.44	6.44
Node 14	6.41	6.41	6.52	6.52	6.51	6.51
Node 13	6.45	6.55	6.57	7.09	6.56	7.04
Node 12	6.59	6.59	7.13	7.13	7.13	7.13
Node 11	7.01	7.01	7.17	7.17	7.15	7.15
Node 10	7.04	7.04	7.23	7.23	7.20	7.20

Table1. Routing of Ant 8059

Node number	Schedule		Real		ACO	
	Arr	Dep	Arr	Dep	Arr	Dep
Node 20	0.00	6.10	0.00	6.16	0.00	6.16
Node 19	6.17	6.18	6.24	6.25	6.22	6.25
Node 18	6.30	6.31	6.34	6.37	6.40	6.41
Node 17	6.42	6.43	6.44	6.48	6.51	6.52
Node 16	6.49	6.50	7.00	7.04	6.53	6.54
Node 15	6.56	6.57	7.18	7.20	7.09	7.10
Node 14	7.07	7.08	7.26	7.30	7.25	7.26
Node 13	7.14	7.25	7.37	7.50	7.35	7.44
Node 12	0.00	7.29	0.00	8.01	0.00	7.53
Node 11	0.00	7.31	0.00	8.04	0.00	8.03
Node 10	0.00	7.34	0.00	8.11	0.00	8.07

Table2. Routing of Ant 8057

Tran number 8040 runs from Kandy to Matara and plotting has started from Node 0 up to Node 10.

Node number	Schedule		Real		ACO	
	Arr	Dep	Arr	Dep	Arr	Dep
Node 0	0.00	9.33	0.00	9.37	0.00	9.37
Node 1	9.43	9.43	9.43	9.43	9.43	9.43
Node 2	9.48	9.48	9.50	9.50	9.51	9.51
Node 3	9.53	9.54	9.54	9.55	9.55	9.56
Node 4	10.01	10.01	10.00	10.00	10.01	10.01
Node 5	10.07	10.07	10.04	10.04	10.07	10.07
Node 6	10.13	10.13	10.09	10.09	10.13	10.13
Node 7	10.18	10.19	10.17	10.20	10.18	10.19
Node 8	10.24	10.24	10.26	10.26	10.24	10.24
Node 9	10.29	10.30	10.33	10.35	10.29	10.30
Node 10	10.36	10.36	10.42	10.42	10.36	10.36

Table3. Routing of Ant 8040

Figure 9 shows a simulation generated by the system for train number 8059. Real time simulations can be produced by the system itself. According to the analysis of results integration of Ant Colony Algorithm with multi agent based system delivered successful results. However, it cannot be achieved global best but final results are very close to the global best. In this research paper it cannot include all results due to page limitations. But in above results clearly show trains are reduced their delays considerably. In train number 8059 schedule arrival time at Node 10 is 07.04 and real arrival is 07.23. After applying this system with ACO, arrival time reduced to 07.20. According to table 3 train number 8040 has arrived scheduled time after applying the system.

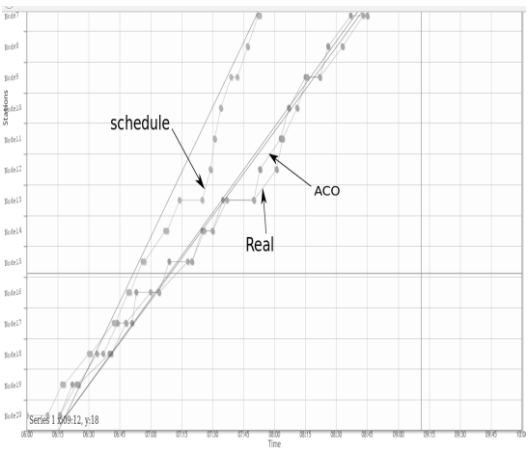

Figure11. Graph of Simulation Ant 8059

However, daily variation in time. But applying of Multi Agent Based System is benefited to both rail travelers and as well as railway management to deliver efficient rail service by reducing delay [14]. This also facilitates to maximize track capacity and train routing. Conflict detection is a crucial benefit received by the system [15]. There are several drawbacks identified and are possible to minimize in future works. Main drawback is number of satellites detected in line of sight. Next one is varying signal strength at time to time and place to place.

Acknowledgement

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References

[1] Transport Research Center, "Managing Urban Traffic Congestion," *European Conference of Ministers of Transport,* pp. 10 - 29 ISBN 978-92-821-0128-5, 2007.

[2] K. A, "Massive Rs 32 bin Loss Due to Traffic Congestion," *Sunday Times,* p. Business Times, 13 March 2011.

[3] G. W. C. D. M. Joseph Bryan, "Rail Freight Solutions to Roadway Congestion," Transport Research Board, Washington D.C, 2007.

[4] F. Y. Wang, "Agent-based Control for Networked Traffic Management Systems," *IEEE intel, Syst.,20(5),* pp. 92-96, 2005.

[5] F. Y. Wang, "Toward a Revolution in Transportation Operations: AI for Complex Systems," *IEEE Intell, Syst.,23(6),* pp. 8-13, 2008.

[6] A. &. P. K. K. Verma, "Mobile Agent Based Train Control System for Mitigating meet Conflict at Turnout," *Procedia Computer Science, Elsevier.,* pp. 32, 317 - 324, 2014.

[7] J. Y. S. W. L. Z. Bing Bu, "Predictive Function Control for Communication-Based Train Control (CBTC) System," in *State Key Laboratory of Rail Traffic Control and Safety, Be, ng Jaotong University,* China.

[8] J. B. M. K. M. B. Khanh Nguyen, "Modelling Communication Based Train Control System for Dependability Analysis of the LTE Communication Network in Train Control Application," in *Conference IEEE EMS, 8th European Modelling Symposium on*

Mathematical Modelling and Computer Simulation, AI Pisa, Italy.

[9] E. O. Hugo Proenca, "MARCS Multi-Agent Railway Control System," in *Universidade da Beira Interior, IT, Inst, Telecom, UBI, R, Marques D'Avila e, Bolama, 6200-001*, Covilha, Portugal.

[10] J. D. C. a. H. W. X, "A New Train GPS Positioning Algorithm in Satelites Incomplete Condition Based on Optimization and the Digital Track Map," in *State Key Laboratory of Rail Traffic Control and Safety, School of Electronics and Information Engineering, Beijing Jiao Tong University*, China.

[11] J. P. Matuschek, "Finding Points within a Distance of a Latitude/Longitude Using Bounding Coordinates," [Online]. Available: http://janmatuschek.de/LatitudeLongitudeBoundingCoordinates.

[12] R. K. G. G. S. C. Krishna H. Hingrajiya, "An Ant Colony Optimization Algorithm for Solving Travelling Salesman Problem," in *University of Rajive Gandhi Proudyogiki Vishwavidyalaya*, Bhopal (M.P).

[13] P. R. M. John E. Bell, "Ant Colony Optimization Techniques for the Vehicle Routing Problem," in *Department of Operational Science, Air Force Institute of Technology, Wright-Patterson AFB, OH*, USA.

[14] K. K. P. Anshul Verma, "Mobile Agent based Train Control System for Mitigating Meet Conflict at Turnout," in *Information and Communication Technology Atal Bihari Vajpayee - Indian Institute of Information Technology and Management*, Gwalier, India.

[15] M. T. S. E. Ali Pouyan, "A Distributed Multi-Agent Control Model for Railway Transportation System," in *School of Computer and IT Engineering, Shahrood University of Technology*, Shahrood, Iran.

Modeling the Learning Ability of Fish in an Artificial Fish Simulation using Reinforcement Learning

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Abstract

Fish display a considerable amount of learning skills in activities like foraging and defense (ex: locations and quality food patches, areas where certain predators are in, etc.). But most of the existing models of fish behavior do not simulate the learning patterns of fish. It makes those models less realistic. This research tries to fill that gap by creating a model with learning ability which is more similar to the actual behavior of the fish. The main focus of this research will be on the learning involving in foraging and defense of the fish. The system will be a comprised of multiple agents to represent fish and each agent will act individually. The senses and the locomotion abilities of the agents in the simulation will be generalized representations of actual fish. And the learning will be simulated using machine learning algorithms.

1. Introduction

Behavioral studies of fish have been carried out in both Animal Cognition and Computer Science fields. In animal cognition, many experiments have been done in order to find the learning pattern of fish and the factors which contribute to those learning patterns. In computer science, especially in the fields of artificial life and artificial intelligence there has been a number of researches conducted in order to find better ways of simulating the behavior of fish.

Fish are the most ancient form of vertebrates which have been living on earth for 500 million years [10]. Because of that, early scientists considered their behavior as a series of fixed behavior patterns released when exposed to appropriate stimuli. Nevertheless, over the last few decades, researchers realized that fish exhibit a rich array of sophisticated behavior and that learning plays a pivotal role in the behavioral development of fish. For an example, fish perform a considerable amount of learning when they are engaged in activities like foraging and defense [1][2]. They learn things like locations and quality food patches and areas where certain predator is in. They can even rank pray and match probability of finding food in certain locations.

If we turn towards computer science, we can see that simulating behavior of the fish is a popular subject in the fields of Artificial Life and Artificial Intelligence. In both of these fields, common behaviors of fish like swarming are being studied and simulated using a number of techniques.

There are a number of applications for these simulations. The main uses of the simulations are games and other entertainment systems such as Virtual Aquariums. Addition to that these simulation are used for researches in areas like animal cognition and biology.

2. Background

Researches in Artificial Life and Virtual Reality have developed many models and applications to simulate the behavior of various animals. Especially, a number of methods and algorithms have been developed in simulating collective behaviors of animals such as fish, birds and insects. They are mostly used in game development, special effects in movies, entertainment (ex: virtual aquariums), etc.. These researches are mostly focused on maintaining the realism and obtaining the optimum performance of the simulations.

There are three main types of approaches in modeling animal behavior.

A Mathematical models

Early studies of behavior used mathematical models in simulating and understanding the particular behaviors like fish schooling. Most often these models use simple rules in guiding individual animal.

The 'boids' computer program created by Craig Reynolds in 1986 is one of the earliest programs that uses these kind of rules [3]. It uses three rules to simulate the behavior of each fish (Figure 1). They are,

- Separation - avoid crowding neighbors (short range repulsion)
- Alignment - steer towards the average heading of neighbors
- Cohesion - steer towards the average position of neighbors (long range attraction)

With these three simple rules, the flock moves in an extremely realistic way, creating complex motion and interaction that would be extremely hard to create otherwise.

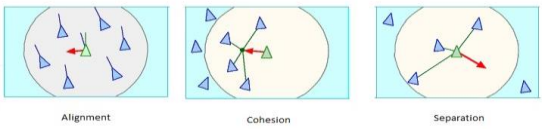

Figure 1: The Three Rules of Boids Model

B Evolutionary models

Evolutionary computing a subfield of artificial intelligence which involves in continuous optimization and combinatorial optimization problems [5]. The difference of these algorithms is that they are mostly influenced by biological mechanisms of evolution. These methods are also used in simulating animal behavior since they can be used to study the evolution of behaviors such as swarm in certain animals.

Mostly these algorithms use genetic algorithms. A genetic algorithm (GA) is a search heuristic that mimics the process of natural selection proposed by Charles Darwin [6]. It finds solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover. In simulations, these algorithms allow models of animals to undergo an artificial evolutionary process through a number of generations and observe the behavior changes in the simulation. These simulations have been used to investigate a number of hypotheses on the evolution of animal swarming behavior such as the selfish herd theory,[7] the predator confusion effect,[8] and the dilution effect [9].

C Agent-Based Methods

In agent based approach each individual in the population is represented by an intelligent autonomous agent. This agent can simulate the actions such as movements, communication foraging, etc. of the particular individual. These individual agents behave independent of other agents while interacting with other agents. The collective behaviors such as swarming and schooling will be emerged through the contribution of actions of each individual agent.

A notable research in simulating fish which uses this particular approach is the research done by Terzopoulos and Tu [4]. It contained a dynamic biomechanical muscular movement model, photo-realistic texture mapping, accurate sensory abilities, a model of desires, and a decision tree based action selection mechanism.

When we consider mathematical models and evolutionary models, it is difficult to use them in tasks such as simulating learning. But agent based models can be used easily in such tasks. Other than that, this approach can be used to model each agent individually that improve the variability of different individual characters. So, agent based models will be the best approach for this particular research.

3. Analysis and Design

The fish show a considerable amount of learning abilities in foraging and in predatory defense [1][2]. When considering foraging fish can learn to identify food through stimuli and also rank them according to the reinforcement they get. When considering defense the fish can identify and avoid the areas which the predators are in.

The system consists of two components 'Agent' and the 'Environment'. The agent is the representation of a fish in the virtual environment and the environment is the virtual space containing obstacles, food, predators, etc.. The agent takes environment data from its sensors and act according to them. Figure 2 shows the abstract architecture of the simulation.

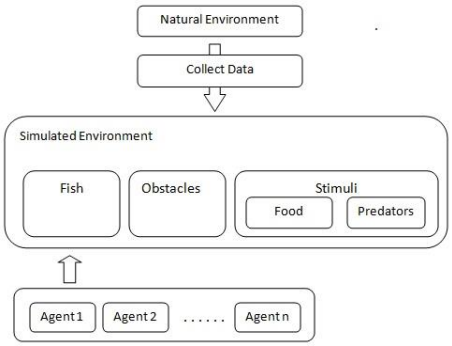

Figure 2: Abstract Architecture of the Simulation

a. Fish (The Agent)

The agent is the representation of a fish in the simulation. Since that it has the ability to simulate the behavior of a fish. Figure 3 will show the overview of an agent.

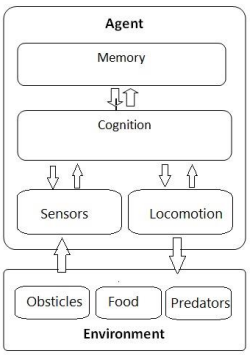

Figure 3: Overview of an Agent

An agent contains several modules that simulate different aspects of the fish.

1) Locomotion

This module controls the movements of fish. The movements which are simulated would be movements towards food, movements away from predators, swarming and collision detection.

The boids algorithm is used in the simulation of schooling behavior [3]. It provides a simple yet realistic behavior pattern to the agents. But if more complex behaviors are required another algorithm can also be plugged into this module. It uses three rules to simulate the behavior of each fish.

Collision avoidance of this model consists of two major components as steer to avoid local collisions with neighbors, and steer to avoid collisions with obstacles. The range of perception of the fish is used as a threshold to detect potential collisions with obstacles and other agents.

2) Sensors

This module simulates the sensory organs that a fish used to take input from the environment. These senses can be visual and chemical since they are the generic senses, which most of the fish have. Figure 4 shows the field of vision of an artificial fish [4].

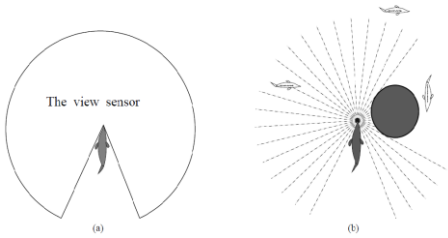

Figure 4: The field of vision of an artificial fish [4]

3) Cognition

This module is in charge of making decisions and learning. This module takes information from memory, sensor module and takes decisions and control locomotion module according to them. Also, this module learns by the reinforcements it gets and stores the new knowledge in the memory module.

An agent has to take decisions on two aspects, foraging and Defense. In each aspect the agent has to do both learning and making decisions according to what it learns.

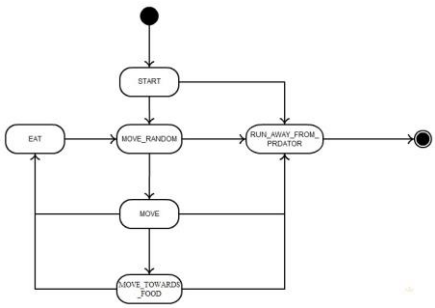

Figure 5: The state machine of an agent

An agent selects its actions according to a finite state machine. The actions of the agent are performed through a loop until the simulation is over or until the agent is destroyed. Figure 5 shows the state machine of an agent.

The functions of each state are as below,

- START – Initial state. When the simulation starts, all the agents are in this state.
- MOVE – Move according to the learned data towards the known food locations. An agent sets into this state when its hunger level is raised above a threshold value.
- MOVE_RANDOM – Move in a school. An agent sets to this state when its hunger level came below the above mentioned threshold. Although the direction of the school is random, it tent to avoid the known predator areas and move around food areas with higher probability. To achieve this probability of choosing between a totally random move and a move from learned data is set to a value decided by experimenting.
- EAT – Simulate the consumption of food. An agent sets into this state when it a food patch appeared in its field of perception. The hunger level is reduced in each time unit that an agent is in this state.
- RUN_AWAY_FROM_PREDATOR – Move away from a predator. An agent sets into this state when a predator appeared in its field of perception.
- MOVE_TOWARDS_FOOD - Move towards a food patch when it appeared in the field of perception of an agent.

Learning is applied in every state of the fish. Temporal difference learning algorithm is used to simulate the learning ability of the fish. It is specifically used for this task because it can be adopted into performing a similar learning process to an organism like a fish. It is also an algorithm majorly influenced by theories of animal learning studied by psychologists [15].

Temporal difference learning (SARSA) is a prediction method. It has been mostly used for solving the reinforcement learning problem. Reinforcement learning allows software agents to automatically determine the ideal behavior within a specific context, in order to maximize its performance. Simple reward feedback is required for the agent to learn its behavior; this is known as the reinforcement signal [13]. Fig 6 shows the action feedback loop of reinforcement learning.

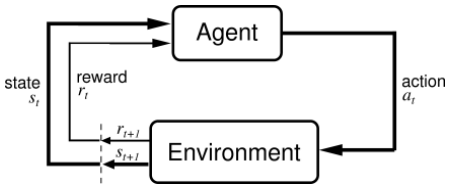

Figure 6: Feedback loop of reinforcement learning [11]

In reinforcement learning, temporal difference learning methods can be used to estimate value functions. The Value Functions are state-action pair functions that estimate how good a particular action will be in a given state, or what the return value is for that action expected to be. Value functions are denoted by V^{Π} (the value of a state under policy Π) [12].

If the value functions were to be calculated without estimation, the agent would need to wait until the final reward was received before any state-action pair values can be updated. Once the final reward was received, the path taken to reach the final state would need to be traced back and each value updated accordingly. This can be denoted as,

$$V(s_t) \leftarrow V(s_t) + \alpha[R_t - V(s_t)] \qquad (1)$$

Where s_t is the state visited at time t, R_t is the reward after time t and is a constant parameter. On the other hand, with TD methods, an estimate of the final reward is calculated at each state and the state-action value updated for every step of the way. This can be denoted as,

$$V(s_t) \leftarrow V(s_t) + \alpha[r_{t+1} + \gamma V(s_{t+1}) - V(s_t)] \qquad (2)$$

Where r_{t+1} is the observed reward at time t+1.

4) Memory

This model contains the data structures that are required to store and retrieve data. The data are stored by the cognition module which is generated by the learning process.

To apply the learning algorithm to this particular problem, the environment is divided into 50 cells, each with a size of 20x20x20 units (Figure 7). The objective of this is to create a location to store a utility value for each location that an agent is in. So the cognition module can update these utility values according to the learning algorithm when it learns and use them to calculate the best direction it should take when it is traveling.

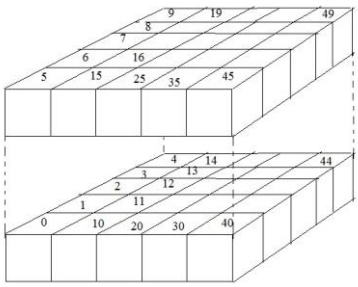

Figure 7: Cell distribution of the environment

The cells aren't given just a single utility value. A value is given for each cell for each time unit in the time cycle. So the value distribution of the cells will be changed through the time cycle also and give an agent a chance to learn about food and predator locations changing through time.

b. Environment

The environment is the module where the fish are interacting with. This module contains the locations and properties of the obstacles, stimuli, predators and other agents. The environment will be modeled as a grid to make it easier for the agents to keep a presentation of the stimuli, predator or obstacle locations. The grid size will be decided depending on the realism of the simulation and the performance of the simulation.

The stimuli contain the position, color and the reinforcement that it gives to the fish. Also the stimuli will appear in the environment within a specific time period. The above properties of the stimuli will be modeled to match the conditions in the real life to maintain the realism of the simulation.

4. Implementation

Implementation of this simulation is created using OpenSteer [16] which is an open source library designed for simulating steering behaviors of autonomous characters like human, animals, other types of creatures or vehicles.

The basic vehicle implementation provided by the toolkit is used to simulate the movement of an agent (fish). First a given number of agents will be initialized with a random position. Then a vehicle will be created for each agent with the same position as the agent. Then at each time step the agent status will be updated and each vehicle position will also be updated according to the agent's new position. Figure 8 will show how agents are represented in the simulation.

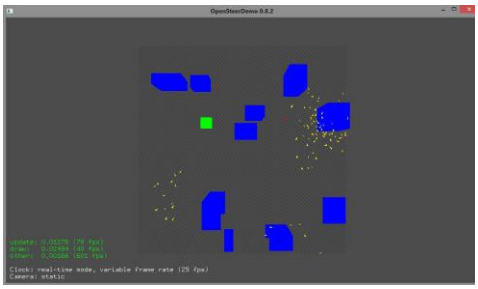

Figure 8: Prototype application

The area of the environment is the weight and the height of 100x100 pixels and the height is 40 pixels. Obstacles in the environment are represented by cubes which can be placed on the floor of the environment to make different settings similar to the natural environment.

The food is represented by smaller cubes, place on the floor of the environment. They have different colors and reinforcement values according to their color. Predators are also represented using vehicle implementation provided by the toolkit. They have random movement around specified locations and within a certain boundary. Figure 9 shows the movement area of a predator.

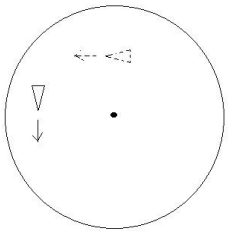

Figure 9: The area which a particular predator moves

Figure 8 shows the overall simulation. Figure 10 shows a moment where the fish are gathered around food patch and figure 11 shows the side view of the simulation.

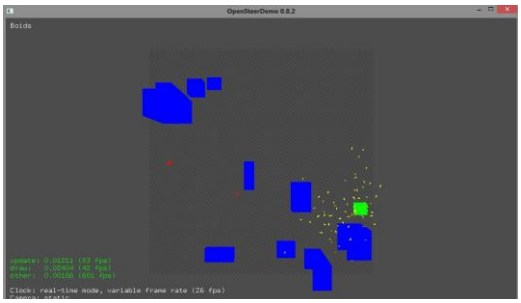

Figure 10: Prototype application – Fish are gathered around a food patch

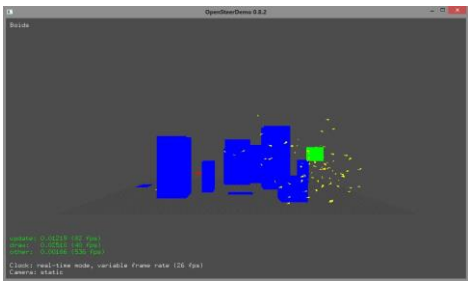

Figure 11: Prototype application - Side view

5. Evaluation

The evaluation of this kind of a research can be categorized into two sections as performance evaluation and user evaluation. Evaluation of this particular project mainly concerns about the performance evaluation because of the lack of expertise in this domain and the time constraints. The performance evaluation is carried out to evaluate the behavior simulation model by changing the conditions such as the number of agents, the number of food patches and the number of predators. The objective is to identify areas that required optimization to reduce memory consumption and execution time.

a. Performance Analysis Methodology

Entire application cannot be effectively used for the performance evaluation. Therefore, only few selected functions are considered here and those functions are selected according to their impact on the simulation. The performance analysis concerns about main functionalities of the application such as initialization, drawing and updating. This simulation application is profiled using Very Sleepy 0.82 [14] which is a C/C++ CPU profiler for Windows systems. All the measurements are taken from a machine with configurations of Intel Corei5, 2.3 GHz processor with 4GB RAM.

Performance analysis is conducted under three sections,

i. Analyses performance by changing the number of fish.

- Initially the number of fish is set to 50, number food is set to 1 and the number of predators are set to 2. The analysis is focused in three main functions known as environment() which is used to initialize each agent, food and predator draw() which handles OpenGL functions and finally the update() function.
- The performance test is conducted separately for samples with 200, 210, 250, 300, 350 and 500 hornets.
- The application inclusive time for above mentioned functions are measured in each sample.

ii. Analyses performance by changing the number of food locations.

- Initially the number of fish is set to 200, number food is set to 1 and the number of predators is set to 2. Then the analysis focus in three main functions environment() conduct initialization, draw() function and update() function.
- The test is conducted separately for samples with 1to 10 food locations.
- The application inclusive time for above mentioned functions are measured in each sample.

iii. *Analyses performance by changing the number of predators.*

- Initially the number of fish is set to 200, number food is set to 1 and the number of predators is set to 1. Then the analysis focus in three main functions environment() conduct initialization, draw() function and update() function.
- The test is conducted separately for samples with 1to 10 predators.
- The application inclusive time for above mentioned functions are measured in each sample.

Furthermore, since profiling cannot be conducted for more than 500 agents, frame rates for updating and drawing are also considered in order to evaluate the performance of the application.

b. Analysis

The application inclusive time for each function are considered for this analysis. This gives the time spent in the specific function and its children without the time spent in the kernel. The application exclusive time, which the individual time spent in the function without its children, was not considered since cohesion of functions.

Even though the application runs well up to 1000 fish, it was hard to take measurements for samples of more than 500 fish while profiling. Therefore, in performance analysis 18 measurements are taken for six samples (200, 210, 250, 300, 350 and 500 fish) and plotted the best fitting curve by using the curve fitting tool provided with the MATLAB application.

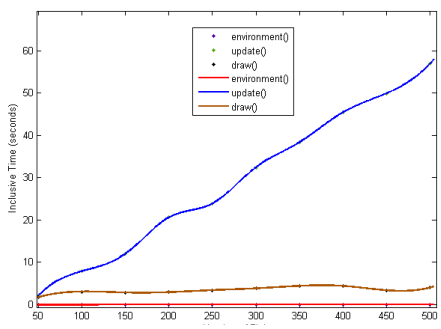

Figure 12: Inclusive times vs. the number of fish.

The graph in figure 12 illustrates the inclusive times that corresponds to the number of fish. It includes the measurements for the three functions which mentioned earlier. As illustrate in the graph, time spent on the initialization (environment() function) and draw() function doesn't exhibit a significant variation up to 500 fish. But the update() functions show a significant change with the increase of the number of fish.

Although the draw() function doesn't increases much it shows slight fluctuations along with the number of fish. On the other hand the update() function also shows similar fluctuations while it is increasing. This may have been due to the fact that 'MOVE' state of a fish gives a one of two outcomes according to a given probability. These outcomes may require different time spans to execute.

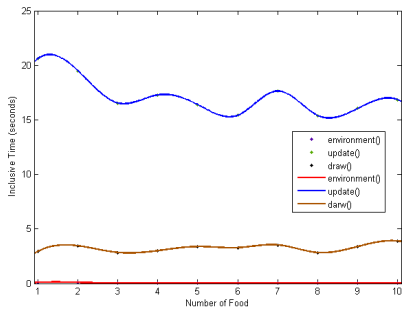

Figure 13: Inclusive times vs. the number of food patches.

The graph in figure 13 shows the inclusive times which correspond to the number of food patches. As you can see from the graph the initializing doesn't take much time to execute and also doesn't have a much increase or decrease. The draw() function also doesn't have a much increase or decrease in inclusive time it is still larger than the time taken by the initialization.

On the other hand the update function has much larger inclusive time, and also it has an overall slight decrease. The reason for this decrease is that the increase of the number of food patches increases the probability of finding a food patch by a fish within its range of perception without moving far. This makes it less likely to choose the best path from its learned data. So it saves the time spent on quarrying its memory. The fluctuations in the both update() and draw() functions are due to the same reason mentioned in the number of fish vs. inclusive time test.

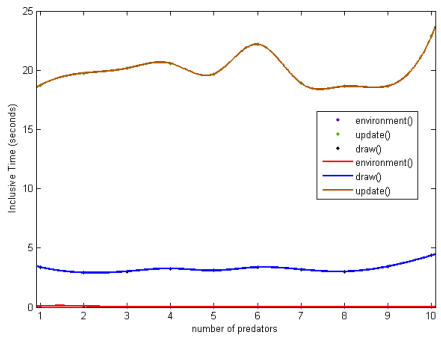

Figure 14: Inclusive times vs. the number of predators

The graph in the figure 14 shows the inclusive times that correspond to the number of predators. This also doesn't show much increase or decrease in initialization and draw() function. But the update() function shows significant fluctuations along the way. This may have the same reason described in the above case. But in here the predators are also moving and it makes the graph to take much more random variation than the above case.

If conclude the result that obtained from analyzing the profiling report, update() function is the most critical function that consume more CPU time. Therefore, the update() function has to be optimized in order to achieve better performance.

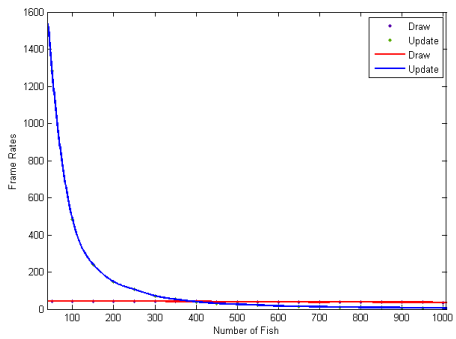

Figure 15: Frame Rates vs. the number of fish.

The second performance test was conducted by considering the frame rate varies according to the change in number of agents. The graph in fig 15 shows the results of the frame rate evaluation. These results also indicate that the performance variation is more tide with the update process than the drawing process. So from this frame rate evaluation, it can be concluded that updating process is the part that need to be optimized in order to get a better performance.

6. Conclusion

Designing a realistic model for simulating the behavior of the fish is a complex task which requires considering many aspects. For a moderately realistic simulation fish can be modeled as automatons which acts on a simple set of rules. But to create a more realistic simulation, higher order behaviors of fish such as learning should be included in the behavior model. In order to fulfill that requirement this paper presents a behavioral model which can simulate learning ability of fish. But considering the time and resources available for the research the scope is limited to the simulation of the learning involved in foraging and defense of the fish only.

The learning aspect in this model is designed using the temporal difference learning. It is a reinforcement learning algorithm which provides a less computationally complex learning mechanism which was ideal for this research. The algorithm was able to learn the locations of food and predators and guide the agents in finding food and escaping predators. Also the algorithm was implemented way that it can also learn the appearance of the food and predators relative to time. Addition to that, the agents are provided with a mechanism for them to find new food locations by performing a certain percentage of their movements randomly. These movements are modeled using Boids model which is a well-known flocking behavior model.

When implementing the application, there were many problems that had to be solved. Finding a better tool for implementing the application was the major issue that involved in the research and had to improve graphics related and mathematical skills in order to carry out the research. With the time constraints, the implementation is done as a prototype by using simple objects to represent fish, obstacles, predators and food patches in the virtual environment. The prototype was built using OpenSteer libraries (open source) that provide basic functionalities for creating a multi-agent based simulation. Even though using simple objects may impact on the user attraction, it has been somewhat successful in giving some idea about their behavior pattern.

When consider the evaluation of this research, finding expertise to conduct a user evaluation was involved as the main issue. Therefore, only performance analysis was carried out to measure the performance of important functions. Finally end of this research; we have to conclude that it has not achieved the goal 100% due to the unavailability of the sufficient amount of experimental data to make the simulation more accurate. So the simulation only demonstrates an approximation of the learning ability of the fish. Further improvements can be used to solve this issue.

7. Future Work

The learning skills of the agents in this model only show an approximation of the learning skills of the actual fish. So the issue that needs the attention is to find sufficient experimental data in order to modify the model to give more accurate output. Other than that the model consider only the generic behavior of the fish. So, looking for ways in which the model can be improved in order for it to simulate particular species of fish is also a task that should be looked into in the future.

In addition to the foraging and defense fish show learning in other types of behavior such as Mate Choice. So extending the model to simulate other types of behavior beside the foraging and defense, is also important to consider when conducting further research. Also, the communication between the fish which includes social learning is also need to be included in future versions of this model.

Acknowledgment

I would like to thank all who gave the guidance and support to make this research successful.

References

[1] Warburton K, Hughes, R , Learning of Foraging Skills by Fish , Fish Cognition and Behavior, 2006, p.10 – 35.

[2] Kelley J. L, Magurran A. E, Learned Defences and Counterdefences in Predator–Prey Interactions , Fish Cognition and Behavior, 2006 p.36 – 58.

[3] Reynolds, C. W. (1987) Flocks, Herds, and Schools: A Distributed Behavioral Model, in Computer Graphics, SIGGRAPH '87 Conference Proceedings, 2006, p. 25-34.

[4] Tu, X. Artificial Animals for Computer Animation: Biomechanics, Locomotion, Perception, and Behavior. Ph.d thesis, University of Toronto, 1996.

[5] D. Simon. Evolutionary Optimization Algorithms. Wiley, 2013.

[6] Mitchell, Melanie (1996). An Introduction to Genetic Algorithms. Cambridge, MA: MIT Press.

[7] Olson RS, Knoester DB, Adami C (2013). "Critical Interplay Between Density-dependent Predation and Evolution of the Selfish Herd". Proceedings of GECCO 2013.

[8] Olson RS, Hintze A, Dyer FC, Knoester DB, Adami C (2013). "Predator confusion is sufficient to evolve swarming behaviour". J. R. Soc. Interface.

[9] Tosh CR (2011). "Which conditions promote negative density dependent selection on prey aggregations?". Journal of Theoretical Biology

[10] Brown C, LalandK, Krause J, Fish Cognition and Behavior , Fish Cognition and Behavior, p.1 –9, 2006

[11] McClelland, James L. , Explorations in Parallel Distributed Processing: A Handbook of Models, Programs, and Exercises. 2 ed , Vol . 2014

[12] "Reinforcement Learning". RetrievedJanuary , 2014 Available: http://www.cse.unsw.edu.au/ ~cs9417ml/RL1/tdlearning.html

[13] "Reinforcement Learning". RetrievedJanuary , 2014 Available: http://reinforcementlearning.ai-depot.com/Intro.html

[14] Mitton, R , "Very Sleepy". Retrieved January , 2014 Available: http://www.codersnotes.com/sleepy/

[15] Andrew G. Barto (2007) Temporal difference learning. Scholarpedia, (11):1604

[16] C. W. Reynolds,"'OpenSteer: Documentation." [Online] Available: http://opensteer.sourceforge.net [Accessed: November 13, 2014].

Intelligent Controller for Inverted Pendulum

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Abstract

Proportional Integral Derivative (PID) controllers are widely using in many control applications, but modeling and tuning of PID controllers are not easy tasks. It needs mathematical modeling and previous experience for doing it. In modern control applications, intelligent control methodologies are used in various approaches. This study focuses on such type of an intelligent control application, inverted pendulum control using an intelligent controller. Inverted pendulum is a famous classical controlling problem. It is unstable and making it stable is a hilarious task. Development of an intelligent controller for feedback's digital pendulum plant is present in this paper. This plant has a single input and two outputs. The hybrid Neuro-Fuzzy architecture used in this paper is ANFIS (Adaptive Neuro-Fuzzy Inference system). This architecture has the essence of the intelligent controllers, neural networks and fuzzy inference systems. Seven linguistic variables are used for each output, Pendulum angle and cart position as well as another seven linguistic variables used for only input control voltage of the motor. To train the neural network a hybrid training algorithm is used. ANFIS controller is showing better result in settling angle, stability, less overshoot and less settling time when compare with existing PID controller.

1. Introduction

At present, modern industrial plants increase their complexities and demand flexibilities that make the design of control systems more difficult. It is known that the conventional control system design requires an explicit mathematical model of the plant. The practical characteristics of the plant such as nonlinearity, complexity, uncertainty are the restrictions of the conventional control systems because the plant model cannot be easily modeled. For an instance, consider the inverted pendulum model. Pendulum Controller is widely used in industries such as rockets, missiles, crane control in shipping forts and self-balancing robots etc. The inverted pendulum system is an unstable classical problem in control systems engineering. Structure of the inverted pendulum and its forces are shown in Figure 1

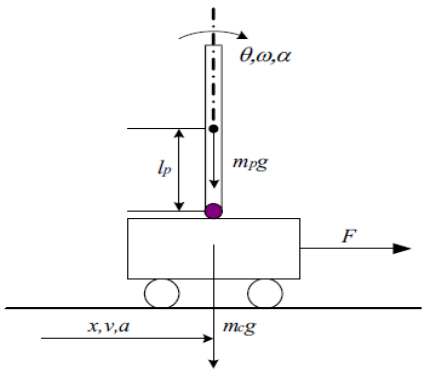

Figure1: Structure of the inverted pendulum

The force *F*, depends on the voltage *v* which is applied to the motor. Control the force which the cart is pulled by this voltage. Therefore voltage is the control signal of the system. Relative position and the relative pendulum angle of the cart can be measured by the optical encoders. An optical encoder consists of a light source, light detector and a slit disk placed between them. This way the relative position with respect to the initial point can be

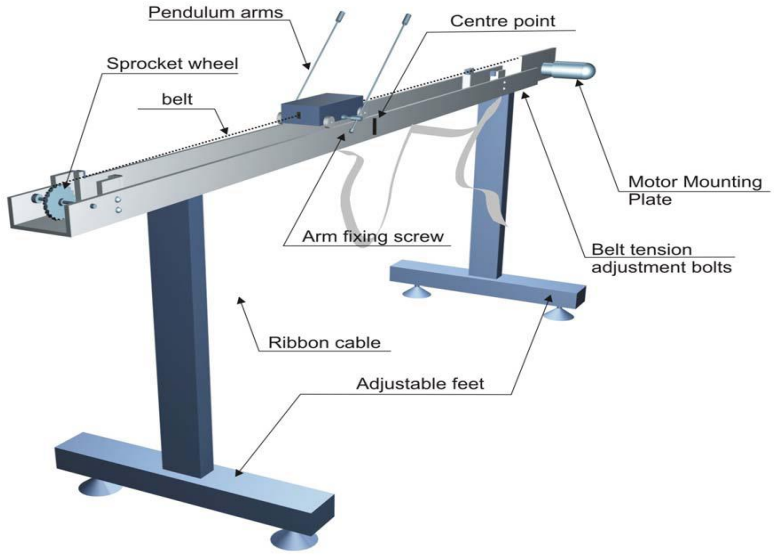

Figure 2: Digital pendulum mechanical unit [2]

measured by counting the pulses on the light detector. There are two input variables (cart position and Pendulum angle) of the controller. The controller will decide the control voltage of the motor. This pendulum controller is a SIMO (Single Input multiple outputs) system [2]. Figure 2 shows a digital pendulum mechanical unit.

2. Design and Implementation of Neuro Fuzzy Controller

For the purpose of controller design models are linearised and presented in the form of transfer functions. Such a linear equality of the nonlinear model is valid only for small deviations of the state values from their nominal value. This nominal value is often called the equilibrium point. The pendulum system has two of these, one is inverted pendulum when θ= 0 and other is crane control when $\theta = \pi$.

When designing the controller, we have to consider input and output parameters. Value for the control signal is set from -2.5V to +2.5V and the generated force magnitude is from -20 N to +20 N. The cart position is bounded by the rail length and the range is from -0.5m to +0.5m [2]. Angle variation in positive and negative directions when the inverted pendulum balances is illustrates in Figure 3. Range of the angle can vary from -180^0 to +180^0.The displacement of cart in positive and negative directions is shown in Figure 4 and this range is from -0.5m to +0.5m. Directions of motor rotating when applying output voltage is illustrated in Figure 5.

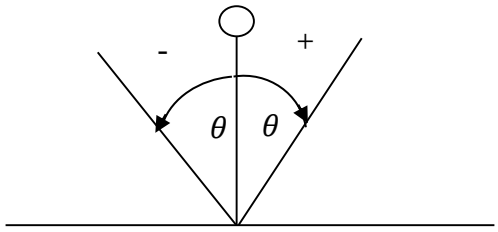

Figure 3: Angle variation in positive and negative directions

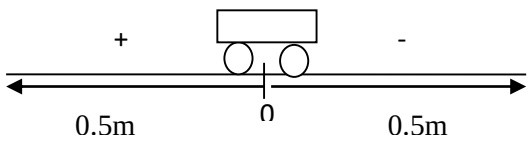

Figure 4: Displacement range of the plant

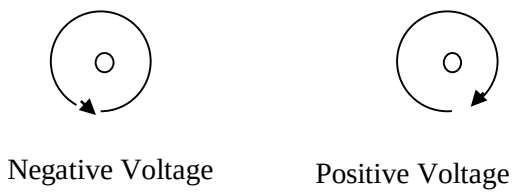

Figure 5: Directions of motor rotating at positive and negative voltages

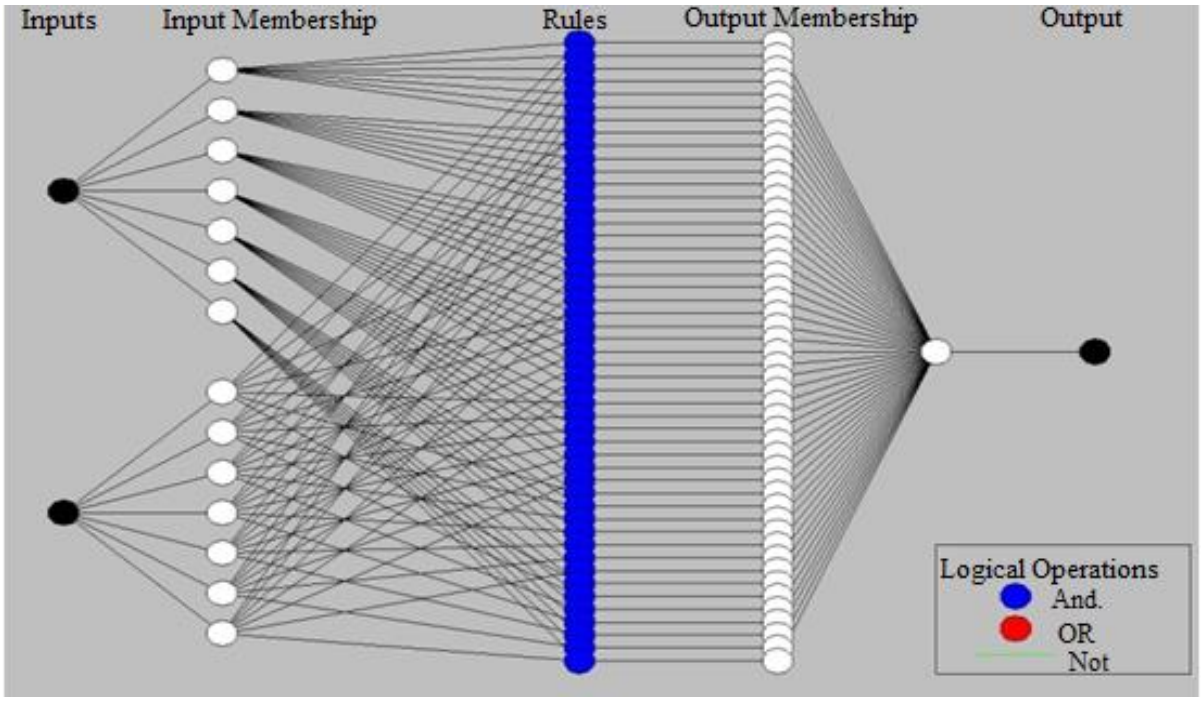

Figure 6: Structure of the ANFIS controller

The Hybrid Neuro – Fuzzy Controller used in this paper is ANFIS (Adaptive Neuro - Fuzzy Inference System) architecture. This is one of the common Hybrid Neuro – Fuzzy architectures and it is called as Neuro like architecture. The Neuro - Fuzzy Controller ANFIS was drawn to implement a Takagi Sugeno type inference fuzzy system. The connections in this architecture are weighted with fuzzy sets and rules using the same antecedents (called shared weights), which are represented in Figure 6. They assure the integrity of the base of rules. The input units assume the function of fuzzyfication interface, the logical interface is represented by the propagation function and the output unit is responsible for the defuzzyfication interface. The process of learning in architecture ANFIS is based on a mixture of reinforcement learning with back propagation algorithm. This neural network consists of five layers, including input, fuzzification, rule base, defuzzyfication and output. Input layer is responsible for getting two input parameters. Fuzzification layer fuzzifies the crisp values to fuzzy values according to the linguistic variables. Membership functions of the rule base is responsible for the fuzzy reasoning in the controller. It applies derived rule set and fires the appropriate rules to get the decision. Finally in the defuzzification layer, it converts the fuzzy values to crisp outputs and transfer to the output layer.

There are two inputs and one output that have to be handled by this system. Each membership function uses seven linguistic variables in this system. Membership functions for angle θ and cart positions are showing in Figure 7 and Figure 8, respectively. The shapes of the membership functions are in Gaussian form. We choose this in the proposed controller, because of its mathematical simplicity, widely use, simple to implement and show good results in other experiments. These functions have been changed after trained the controller.

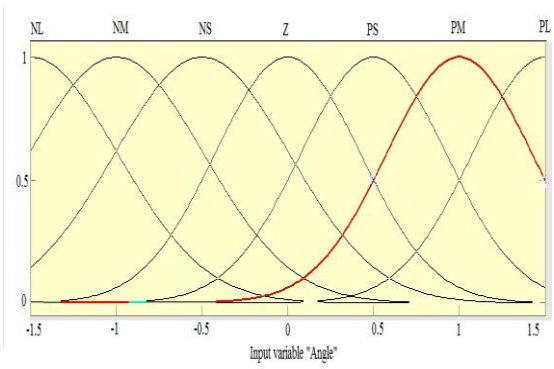

Figure 7: Membership function of Angle θ

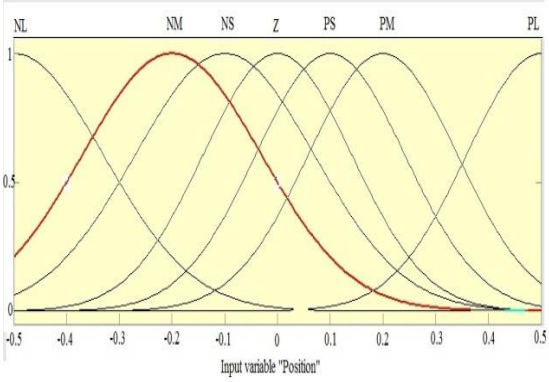

Figure 8: Membership function of Position

Table 1 illustrates the rule base of 49 rules constructed using input and output linguistic variables.

θ / D	NL	NM	NS	Z	PS	PM	PL
NL	NL	NM	NS	NL	PS	PM	PL
NM	NL	NM	NS	NM	PS	PM	PL
NS	NL	NM	NS	NS	PS	PM	PL
Z	NL	NM	NS	Z	PS	PM	PL
PS	NL	NM	NS	PS	PS	PM	PL
PM	NL	NM	NS	PM	PS	PM	PL
PL	NL	NM	NS	PL	PS	PM	PL

Table 1: Fuzzy rule base

where,
NL – Negative Large
NM – Negative Medium
NS – Negative Small
PL – Positive Large
PM – Positive Medium
PS – Positive Small

3. Training ANFIS controller

By comparing the signals, the actual output and the desired output of the controller, we can generate the error at every instant. Then the adjustments of the input and the output membership functions can be generated by back propagating the error through the "neural-like" architecture of the fuzzy controller. The essence of back propagation algorithm in this case is to reward those rules which contribute towards taking the actual control action to the desired control action and to discourage the rules which tend to take the control action away from the desired path. Real time simulation of existing plant with PID controller is used to collect the data set. Figure 9 illustrates the collected data set and it consists of 50000 data pairs for inputs and for output voltage. For training the ANFIS controller, we used fuzzy controller GUI in mat- lab.

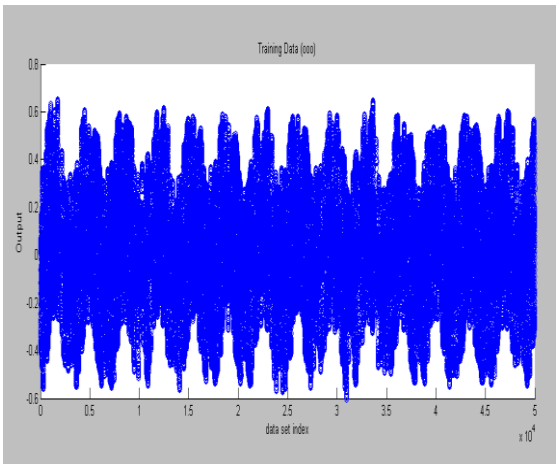

Figure 9: Collected data set

After loading the training data set to ANFIS controller interface, select the training method as Hybrid and the number of epochs as 100. Figure 10 illustrates the reducing of the training error with the number of epochs.
After training, three times the error becomes zero and it remains the same value during 100 epochs for each. Figure 11 illustrates error after becomes zero.

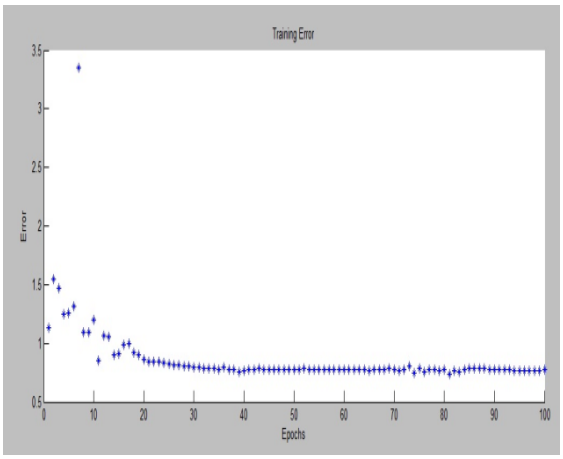

Figure 10: Training error decreases during training

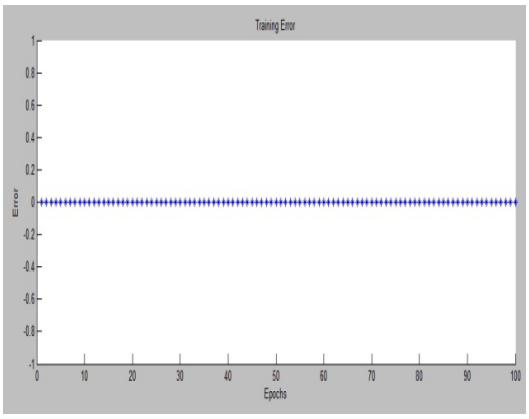

Figure 11: Training error zero

4. Test Results

Finally ANFIS Controller achieves the goal of this project. It can achieve better stability in angle of the Inverted pendulum. When compared with the PID Controller ANFIS controller can have a stable angle like a well tuned PID controller and some cases ANFIS controller achieved more stability than PID controller. Figure 12 illustrates the settling angle of both systems. It's clearly seen that ANFIS controller has less overshoot (less than 0.05 radian) than PID controller (0.2 radian). Settling times of both controllers are approximately same but ANFIS controller (three milliseconds) achieved it before PID controller (six milliseconds). When the angle becomes zero, ANFIS controllers get settled but PID controller gets few more milliseconds to settle. After the settlement both controllers maintain the angle to zero position in Inverted pendulum.

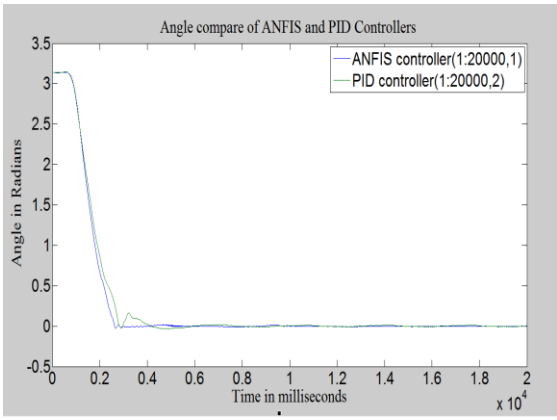

Figure 12: Settling angles of the PID controller and ANFIS controller

It also reduces the distance travel when balancing the pendulum. When comparing with well-tuned PID controller ANFIS controller travels low distance for balancing it and sometimes it try to be stable without movement. PID controllers always maintain constant distance to balance the pendulum. But ANFIS controller maintains various distances for balancing and that displacement is less than PID controller's displacement. Figure 13 illustrates the comparison of the position of PID controller and ANFIS Controller. Maximum displacement range of PID controller is between -0.02m to +0.02m. But ANFIS controller has less displacement range that is between -0.01m to + 0.01m.

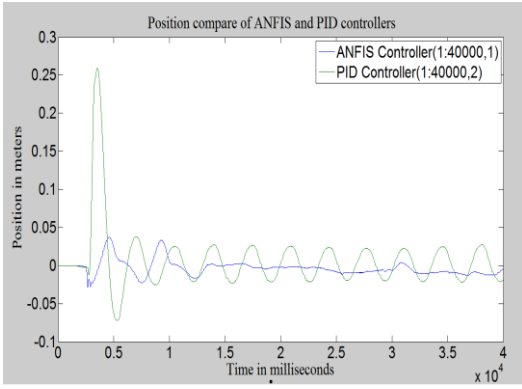

Figure 13: Comparison of the position of the PID Controller and ANFIS Controller

Figure 14 illustrates the comparison of the output voltage for both systems PID controller and ANFIS controller. It is clear that the output voltage of the system is very similar in both cases.

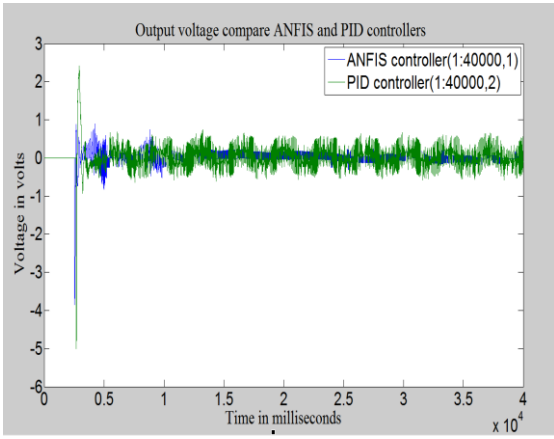

Figure 14: Output voltages of the PID controller and ANFIS controller

5. Conclusion

Hybrid architectures in AI solutions are widely use in modern era, because hybrid architectures can represent two or more AI techniques and harness the power of both techniques. This controller use Neuro –Fuzzy architecture. It is a hybrid solution from joining Artificial Neural Networks and Fuzzy Logic. Artificial Neural Networks has ability to train and adapt to the situations according to the trained data set. Fuzzy controller has ability to make decisions according to the fuzzy rule set. When join these two techniques, Neuro-Fuzzy hybrid controller can able to adaptive the fuzzy inference engine. That is why this controller uses Neuro-Fuzzy system.

Proposed controlling approach mainly focuses on Artificial Intelligence. This Intelligent controller provides good alternative solution to mathematically modeled PID controller. It is more accurate, efficient and low complexity than PID. Normally tuning PID controller is very difficult task and it will consume more time. But this controller does not have any tunings process, ones it trained and it can be used.

References

[1] Chetouane, F, Darenfed , S & Singh, P K 2010, Fuzzy Control of a Gyroscopic Inverted Pendulum.Available at: www.engineeringletters.com/issues_v18/issue_1/EL_18_1_02.pdfAccess Date: 15/08/2011

[2] Chih-Hui Chiu and Chun-Hsien Lin, A WIP control based on an intelligent controller
Department of Electrical Engineering, Yuan-Ze University, Taiwan
Available at : http://www.waset.org/journals/waset/v78/v78-126.pdf
Access Date: 04/09/2011

[3] Digital Pendulum control Experiments, Feed Back instruments limited, Park road, crow borough, East Sussex, TN6 2QR, UKManual: 33 – 936S (For use with MATLAB R2006b version 7.3)

[4] Djamel, EC & Hichem, MAAREF 2009, Intelligent Control of an Inverted Pendulum by Self-Tunable Fuzzy PI-type Controller, Faculty of Sciences and Technology, University of Mascara, Algeria,2IBISC Laboratory, University of Evry Vad"Essonne, France
Available at: www.atlantispress.com/php/download_paper.php?id=2188. Access Date: 04/09/2011

[5] El-Bardini, M. and El-Nagar, A.M., 2014. Interval type-2 fuzzy PID controller for uncertain nonlinear inverted pendulum system. *ISA transactions*, *53*(3), pp.732-743.
Available at: http://www.sciencedirect.com/science/article/pii/S0019057814000391
Access Date: 11/12/2015

[6] El-Nagar, A.M., El-Bardini, M. and EL-Rabaie, N.M.,2014. Intelligent control for nonlinear inverted pendulum based on interval type-2 fuzzy PD controller.*Alexandria Engineering Journal*, *53*(1), pp.23-32.
Available at: http://www.sciencedirect.com/science/article/pii/S111001681300118X
Access Date: 11/12/2015

[7] Elmer P. Dadios, Patrick S. Fernandez, David J. Williams, 2005, Genetic Algorithm on Line Controller for the Flexible Inverted Pendulum Problem, Department of Manufacturing Engineering and Management, De La Salle University, Philippines, National Power Corporation, Philippines, Loughborough University,U.K.
Available at : http://www.fujipress.jp/finder/xslt.php?mode=present&inputfile=JACII001000020004.xml
Access Date: 04/09/2011

[8] Gurpreet S. Sandhu & Kuldip S. Rattan, Design of a Neuro Fuzzy Controller, Department of Electrical Engineering,Wright State University, Dayton, Ohio 45435
Available at : http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=633083&url=http%3A%2F%2Fieeexplore.ieee.org
Access Date: 23/01/2012

[9] Jung, S. and AHN, J., 2011. Remote Control of an Inverted Pendulum System for Intelligent Control Education. *International Institute of Informatics and Cybernetics*, *9*, pp.49-54.
Available at: http://www.iiisci.org/Journal/CV$/sci/pdfs/QN067RH.pdf
Access Date: 11/12/2015

[10] Khwan-on, S, Kulworawanichpong, T, Srikaew,A & Sujitjorn, S 2010, Neuro-Tabu-Fuzzy Controller to Stabilize an Inverted Pendulum System, School of Electrical Engineering, Suranaree University of Technology, Thailand
Available at : http://sutlib2.sut.ac.th/Sut_Article/Sarawut/BIB979_F.pdf
Access Date: 23/08/2011

[11] Steven D. Kaehler, Fuzzy Logic Tutorial
Available at : http://www.seattlerobotics.org/encoder/mar98/fuz/flindex.html Access Date: 15/01/2012

Ontology Development for Sri Lankan Medicinal Plants: A Knowledge Representation

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Abstract

Our ancestors consumed medicinal plants through their day to day activities which leads them to a long and healthy life. It plays an important role in their life. But in this fast moving world the value of these plants are gradually going down. As they take comparably long time to give relief from the disease, the people are not interested in these medicines. Fast and modern foods are replaced our traditional food system which lessen the intake of herbs through foods. We have responsibility to aware our future generation about this medicinal plants and their usage, because they are in danger of extinct. The knowledge about these plants are scattered over the web and some experts are still here to carry this knowledge to our future. This research aims to collect all these knowledge from different places and build a knowledge base system for Sri Lankan medicinal plants. This knowledge base consist plants parts, diseases, preparation method and mixtures if any. Ontology is the technique used to develop the knowledge base. To develop the ontology, Protégé which is an open source is used. SPARQL is the language used to query over this knowledge base.

1. Introduction

Sri Lanka is a country of rich history and heritage. An important one among them is the indigenous system of Medicine. The traditional medical practices were developed over generations enriched with the Ayurveda system of medicine from North India, the Siddha system of medicine from South India and the Unani system of medicine of Arabs and presently known as the Indigenous system of medicine in Sri Lanka. Sri Lanka is blessed with a large variety of flora in which many of them have some medicinal properties. Each part of a plant as leaves, flowers, roots, seeds and barks have different properties and plays a vital role in indigenous medicine as well as for home remedies many Sri Lankans commonly practice for centuries. Due to fast-phased life style indigenous medical practices became unpopular and the knowledge of these valuable plants is in danger of being lost forever. Our ancestors consumed various plants through their daily meals and used them in their day to day household tasks from brushing the teeth to sleeping. These practices and the knowledge are mostly forgotten now. Because of the lack of awareness these plants are often destroyed as weeds or unwanted plants and in danger of extinct.

These issues motivated to create an information system to store the details of the medicinal plants, their properties and details of indigenous practices related to the plants in such a way to retrieve the correct details for partial and vaguely detailed queries. Methods will be identified to retrieve details by providing pictures as well. The system will be modeled to store the details appropriately such that it can be used as a decision support system for indigenous medical practices to know, protect and use plants for a healthy and environmental friendly living.

Even this medical system has some issues which are not suited for this fast moving world. It takes comparably long time to cure the disease. But we expect a fast remedy and not consider about the other facts. Also it takes some extra works to get the final medicine while we have readily available medicine which will save our time. We need to identify the plant, collect the plant parts as well as we need to prepare it to make the medicine. It also very time consuming task. These factors also play a big role in the extinct of this herbal medicine. But this research aims to make aware our youngsters about the advantages of this medicine which will overcome all the disadvantages. It will lead the youngsters to easily find out these plants and their preparation method.

Research will focus on identifying appropriate methods for developing a knowledge base of medicinal plants including their pictures and usage. Research will also focus on developing an inference engine that can answer queries regarding the medicinal plants and their usage. The queries could be vague, may have information in various forms such as text (about the plant or the usage) or a picture of the plant (or part of it) and may contain noise. As a result a prototype expert system would be developed. About 200 plants are studied and their medicinal properties have been collected from the book Indian Medicinal Plants by KRITIKAR & BASU which is the main reference by Siddha medicine students.

Collected knowledge is structured into classes, sub classes and instances. Finally they are connected through relations in a proper way. The following sections are as follows: Next section is literature review which describes the existing works in this area. Third section is Methodology which is used to discuss the technique used in this work. After that result section, obtained result in this work is explained here. Finally conclusion and future works, in this section used techniques in this work and results are discussed. Future improvements or continuity of this work also stated in this section.

2. Literature Review

First point in this research is to find out the best technique to represent the knowledge. Few papers are analyzed to find out the best technology. Finally ontology is chosen as the better technique than others which has comparable advantages over rules, frames and semantic nets, other important knowledge representation techniques. Particularly most recent medical systems have used ontology as their knowledge representation technique [2], [3], [4], [5], [6] and [8]. They have discussed the steps involved in the ontology development for their methodologies. This research related with medical field so they give some important facts as the important information to be collected in order to build ontology, the things that can be expected from the users in this system and the idea of creating a user friendly interface.

[11] And [12] discussed the common ontology development techniques, Steps include in this development and the challenges in this development. [11] Says the main steps involved in ontology development. They are enumerating all important terms in the domain, identifying terms definition and related meaning, defining classes and class hierarchy and finally identifying relationship between classes. Two types of relationships exist in Protégé as object property and data properties where object properties define the relationship between instances or classes as well as data properties define the attributes of instances.

Then the ontology editors and their comparisons play a vital role in this research. We need to choose an appropriate editor to create our developed ontology. In [10] some ontology editors are compared. They have compared some editors as Apollo, OntoStudio, Protégé Ontology Editor, Swoop and TopBraid Composer Free Edition. Protégé has comparable advantages over others. They took some general facts as general description of the tool, Software architecture and tool evolution, Interoperability, Knowledge representation, Inference service and Usability to compare them. Protégé is an open source system where no license is needed to use it. Plug-ins can be used to extend the service and it can be easily added to the system.

Finally, plant classification and the identification of plant parts and their category, which is the main task in this research. [13] is a very useful reference in this category. It is a complete reference in categorization of plant parts. Monocot and dicot are clearly differentiated in this paper. The major differences of these two types are stated clearly. Then they discussed the attributes of a leave and the values for those attributes. They are leaf arrangement, leave type, leaf shape, leaf margin and leaf attachment. The values for these attributes also

stated clearly. Like that flower and root also analyzed through this paper. Some interesting facts about the plants can also be collected from this paper.

3. Methodology

This section describes the methodology used in this research. As stated in previous section the ontology development includes four important steps. First we need to enumerate all important terms in this domain. This section covers the following concepts:

- List of important terms which will use to explain our domain to the user.
- Properties and relations of those terms.
- What we are trying to say through these words.

This research aims to build a knowledge base system for herbs. It includes the preparation method, any mixtures and the corresponding diseases to that preparation. So first we need to specify all the terms related with this domain. Most of the terms are related to medical field. So we need to find out the terms carefully as it is new to us.

Next thing is identifying terms definition and related meaning. First we need to find out the plant names. It includes family name, genus, species and binomial name. More over each plant has some unique attributes. All of those attributes need to be mentioned. Consider a family of plants which can be classified it into many sub classes as trees, shrubs, climbers, creepers, herbs or weed. Each of these families has different type of attributes. Here, lot of diseases are considered in a similar way. Then we need to identify all type of diseases and its characters.

Next thing is preparation method which means how we can prepare the plant part to get the final form of medicine. Various types of preparation methods are used in this research. All of those preparation methods need to be identified here. Each main method has different sub methods. So main methods are sub classes of preparation method which is a main class and these sub methods are instances of main methods. Say Juice is the main preparation method which has instances as expressed juice, fresh juice, milky juice, etc. Like that all the preparation methods have its instances. So Juice is a sub class under preparation method and those three variety juices are instances under Juice. Another one is application category which indicates how to apply the medicine. We have to find out the application categories related to each method.

The mixture is the thing that to mix with prepared medicine before we consume it. Different types of mixtures are available with medicine. It is required find out the categories or classes related to this mixture and their attributes. This gives finally all the related terms and their related meanings. In this phase it is identified terms as class names, sub class names, instance names, all the attributes and relations related with them and values for those attributes.

Next main step is defining classes and class hierarchy. According to identified terms the main classes are Plants, Diseases, Application Categories, Preparation methods and Mixture. Most of them have sub classes where plants have the subclasses namely plant parts, trees and small trees. Then small trees have subclasses as shrub, climber, creeper, herb and weed. Hence this is the hierarchy of plants. Then all of the plant instances are being put into the proper classes. In this study disease is not categorized into classes. All of the diseases are assigned within the class disease. So class disease has no sub classes.

In case of Application Category, it has no subclasses. Only instances are defined under application category class. About twenty five types of application categories are defined here. Next main method is Preparation method which consist different preparation methods as its sub classes. These sub classes have related preparation methods as instances. Finally mixture is another main class. It has sub classes as milk, oil, spice and other mixtures. Each of these sub classes have proper instances related with them. All of these main methods are defined under a super class called Thing which is a pre-defined class in PROTÉGÉ. **Error! Reference source not found.** shows the class hierarchy of studied classes in this research.

Each of these classes has its own instances. About 200 plant instances are represented here. More than 200 parts are represented in this research. 80 to 90 diseases are cured by these plants. About twenty five application categories are mentioned here. Like that preparation method and mixture also has their

instances. All of the terms related with them are enumerated in first step.

Finally we need to identify the relations between these classes. Two types of relationships are defined in PROTÉGÉ. First one is object property which is used to relate one instance from another and the other one is data property which is used to describe each

instance. So each property of instances is defined using this data property. Each object property has its inverse property. Relations, inverse relations and the corresponding classes are clearly stated in table form which is

Table 1:

Relation	Class1	Class2	Inverse relation
Applied	Preparation method	Application category	Applied on
Cured by	Disease	Plant part	Used to
Mixed with	Preparation	Mixture	Used with
Part of	Plant part	Plant	Used part
Processed on	Preparation method	Plant part	Used method

Table 1: Relations and Inverse relations defined in this study

In ontology development all these object properties have a top class called top object property. Next one is defining data properties. We need to represent all the attributes of each class through this data property. We have defined nearly fifty data properties related with all classes. All of them have different values and those values will change from instance to instance. Like object property these data properties have a super class called top data property. So these properties also have a class hierarchy under their super class.

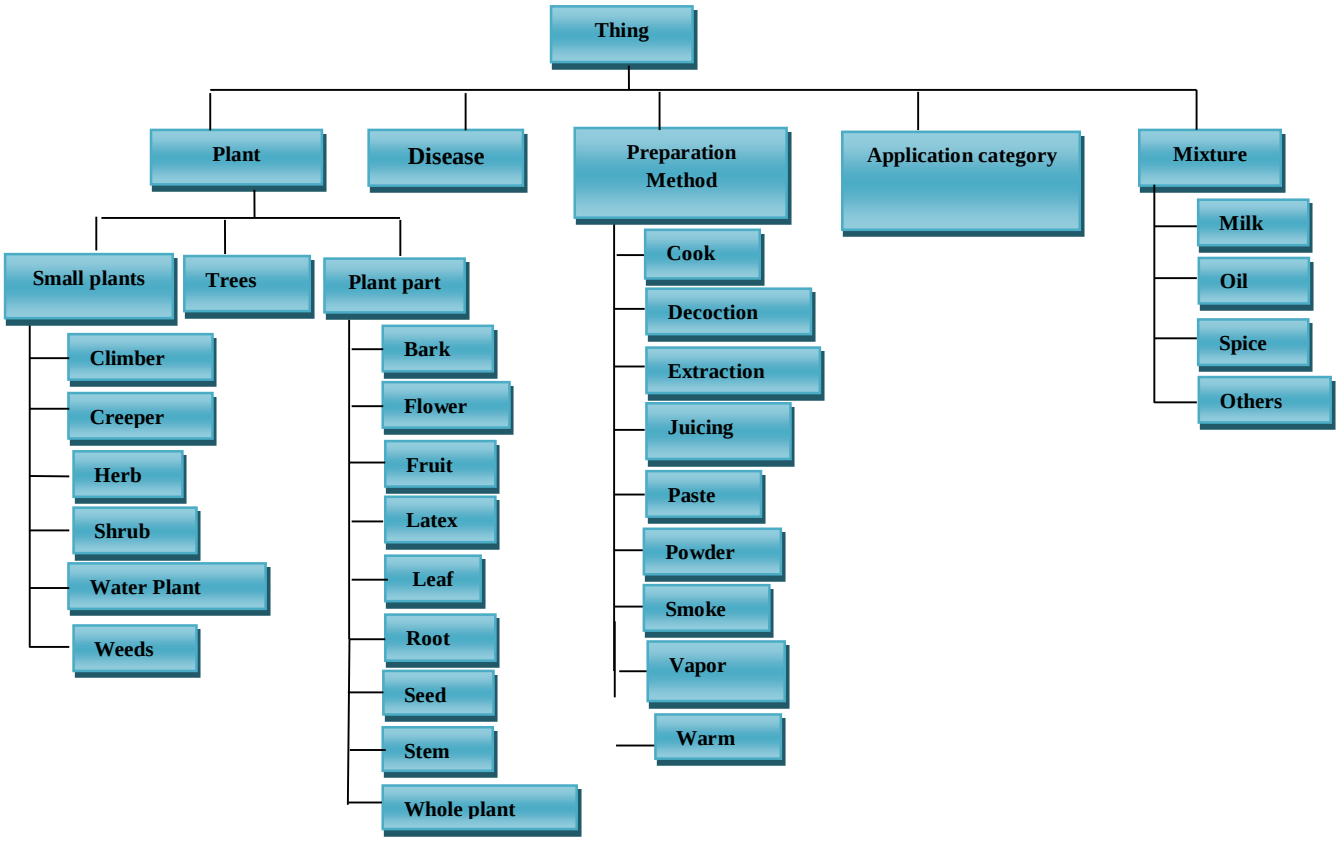


Figure 1 Classes and sub classes

4. Results

This section describes the obtained results of this research. Methodology describes the classes and its relationships. Each class needs to be related with others. If we consider a plant it has its part. Those parts need to be prepared before we consume it.

Then the prepared plant part needs to be mixed with the mixture if exist. Finally this medicine has a medical usage. These properties need to be mentioned through some relations. Some samples of the above description are given in

Table 2:

Plant	Plant part	Preparation method	Mixture	Application category	Medical usage
Arasu	Bark	Juice	None	Mouth wash	Toothache
					Strengthen the gum
Aambal	Flower	Decoction	None	Orally	Palpitation
Malaiyamanakku	Latex	Applied over	None	Externally	Wounds
Aadhathodai	Leaf	Fluid extract	None	Orally	Cough
Karuntulasi	Fresh root	Ground with	None	Externally	Stings of wasp and
Ellu	Seed	Pound	Jaggery	orally	Purify blood
Kattukkilanelli	Stem	Juice	None	Blow into eyes	Sore eyes
Palaa	Whole	Juice	None	Externally	Grandular swelling

Table 2: Sample data used in knowledge base

A sample of the overall representation of herb knowledge is shown in the above table. Like this all the received herb knowledge is represented to build the complete knowledge base. It shows a picture of the knowledge base or it creates an idea about the knowledge base and its functionality.

Then we need to think about the data property. It is completely different from object property where object property is used to represent the relationship and data property is used to represent the attributes of instances. Each class has its own attributes and these attributes will change from class to class. As well as the values of these attributes will change from instance to instance. So we need to assign proper property values for each instance in this knowledge base. Data properties related with some important classes are indicated in Table 3. More than the indicated properties each plant has some common properties as family name, species, genus and binomial name.

Climber	Stem character	Tree	Stem stability
	Stem stability		Height
	Life		Life
	Stem type		Stem type
Creeper	Stem character	Weeds	Found in
	Stem color		Grow speed
	Grow along		Life
	Stem stability		Height
	Life		Stem type
Shrub	No of Branches	Herb	Stem color
	Height		Stem character
	Stem character		Stem stability
	Stem size		Stem type
	Stem type		Height
	Life		Life

Table 3: Data properties of class Plant

Like this class 'plant part' has own data properties of it. Plant part has sub classes as barks, flower, fruit, latex, leaves, root, seed, stem and whole plant. Most of them have attribute values and they are showed in Table 4

Flower, Fruit, Seed	***Leaf***
-Color	-Color
-Shape	-Arrangement
-Size	-Attachment
	-Margin
Root	-Shape
-Root system	-Type

Table 4: Data properties defined for plant parts

Ontology is the technique used to develop this knowledge base. PROTÉGÉ-5.0.0-beta-16 is used to develop this ontology. All the classes are under a super class called Thing. The structure is shown in **Error! Reference source not found.**. Structure of the object property and data property of these classes are given by **Error! Reference source not found.** and Figure 4 respectively:

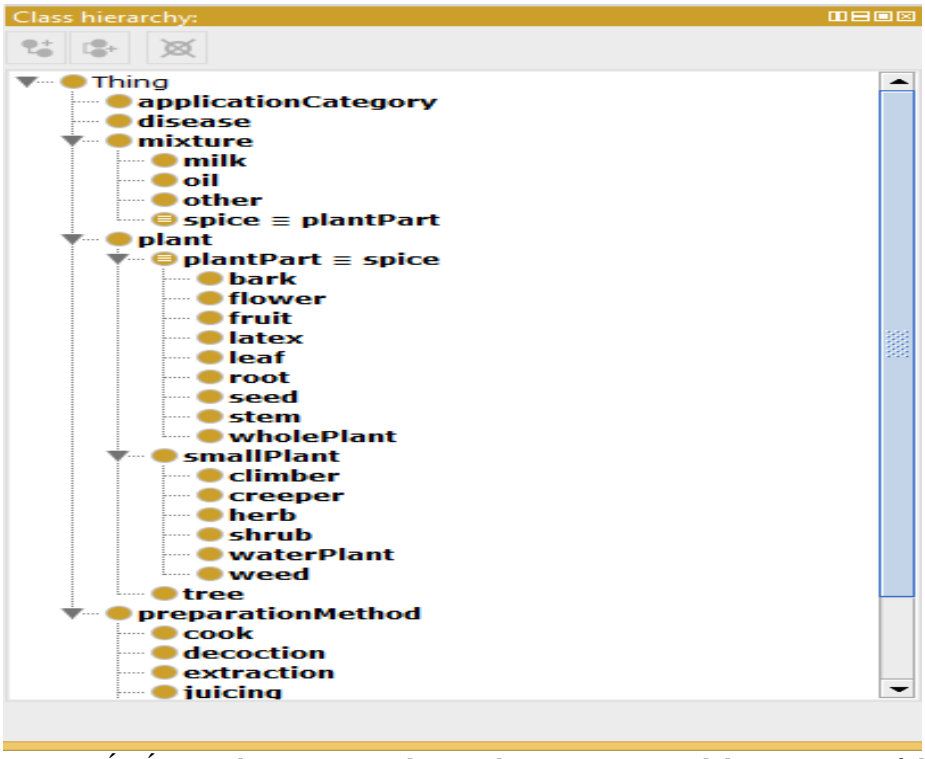
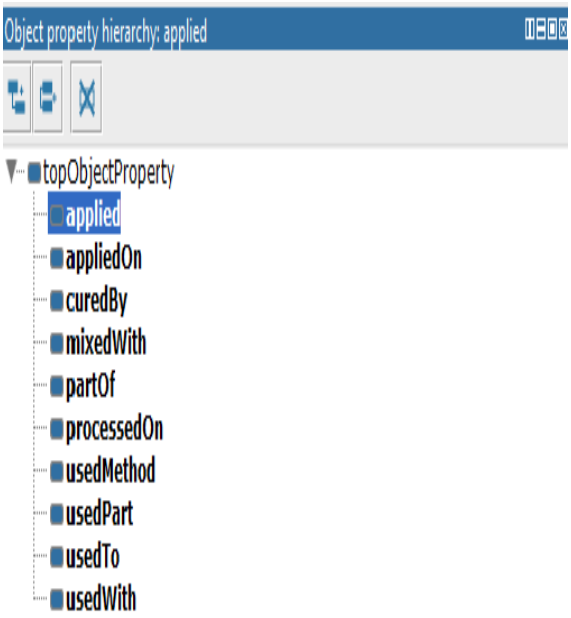
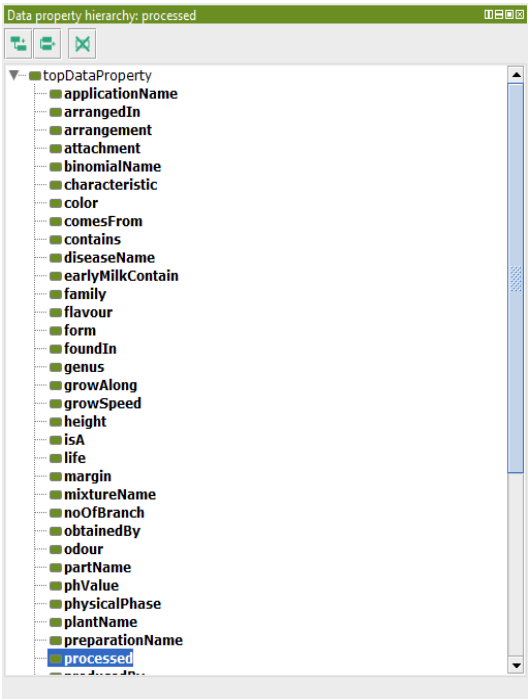


Figure 2: Ontology classes and sub class





Each property has a domain to give the class related with this property and a range to specify the range of property values like string or integer.

PROTÉGÉ has the facility to get the graph model of developed ontology. OntoGraf is an application (a plug-in) which will give the facility to get those graphs. **Error! Reference source not found.** and **Error! Reference source not found.** shows the overall relation and structure of the herbal knowledge of Sri Lankan medicinal plants respectively.

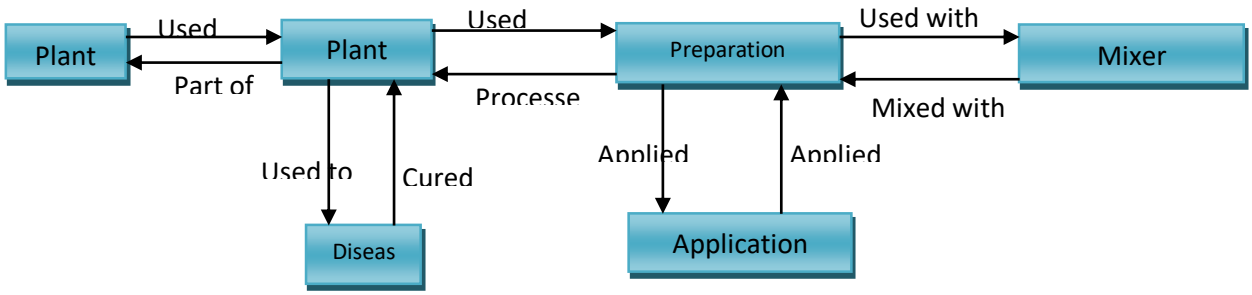


Figure 5: Main classes and their relations

Figure 3 : Object properties

Figure 4 Data properties

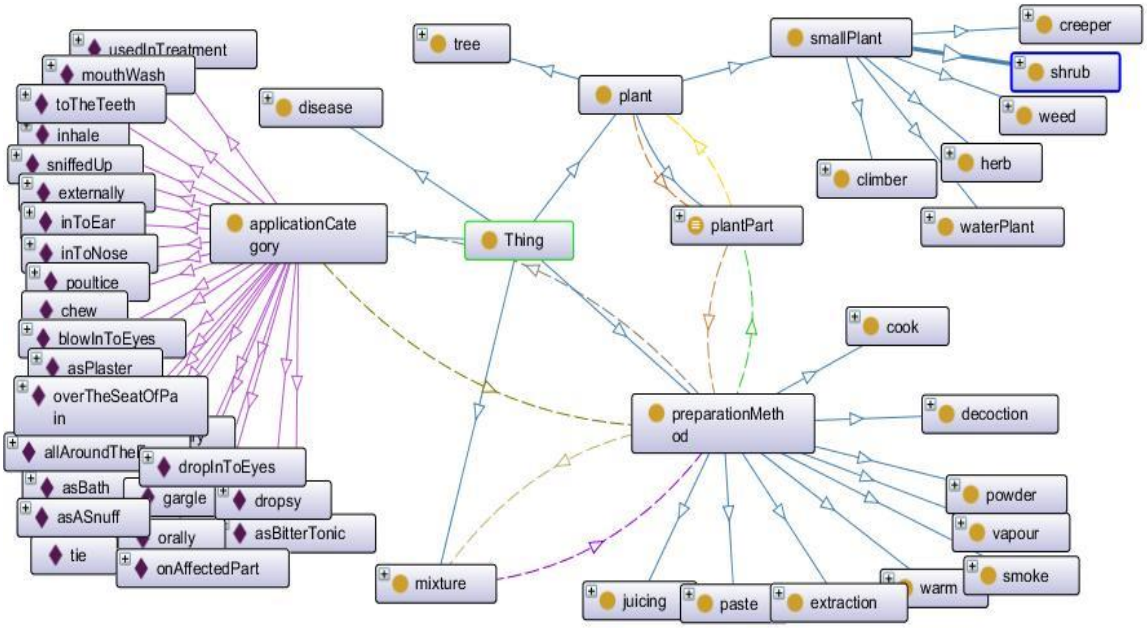


Figure 6: Overall structure of the herb ontology

The knowledge base can be searched through this application. We can give a keyword and search the entire knowledge base for that keyword. The result will be a graph with the keyword and its related terms. For example we may search for a disease, in this case for catarrh. The result was represented in **Error! Reference source not found.**. It shows the disease catarrh and the plants which can be used to cure catarrh. Then its corresponding preparation method and other parts included in this preparation method and so on.

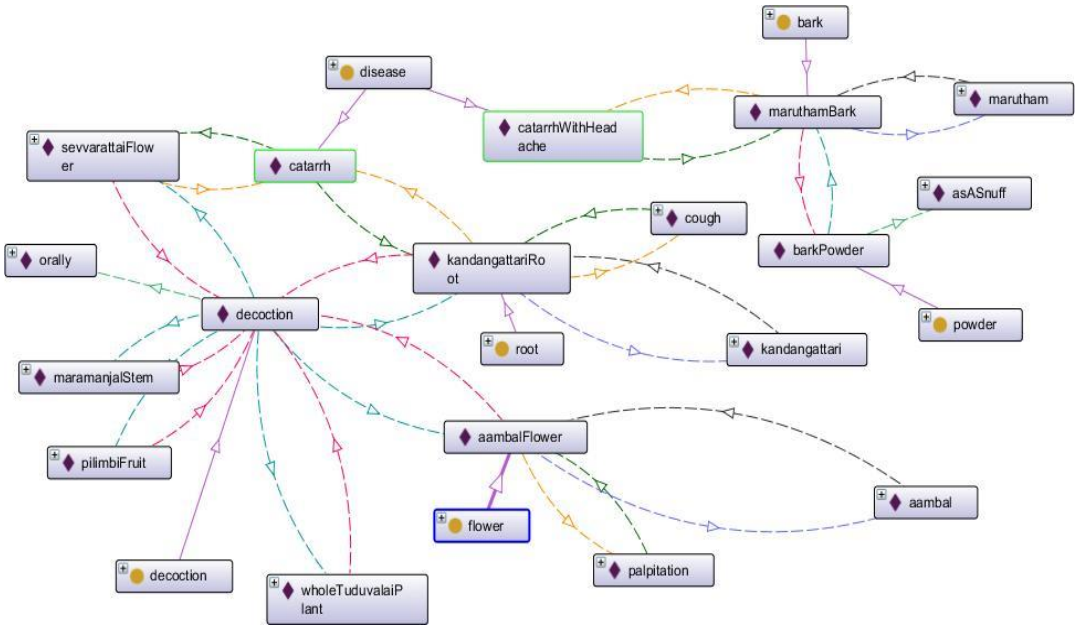


Figure 7 Related terms and definition with disease catarrh

5. Conclusion and Future works

This research focuses on the importance of the herbal medicine and finally it came up with a knowledge base for these medicinal plants. It mainly concentrates on the herbal part and its preparation method. About 200 plants are analyzed in this research to build this knowledge base. Ontology is the technique used to build the technology. It is a technique which has notable advantages over other techniques. We can reuse this ontology for some other applications with required changes. It represents the knowledge in the form of class, sub class and instance. PROTÉGÉ is the tool used to build the ontology. It has advanced features to represent the ontology and it will support several languages to query the knowledge base. Here SPARQL is used to query this knowledge base. Apache Jena with eclipse is used to design the user interface. This development will gain better understanding on the concept and will meet the expectations about the indigenous flora of Sri Lanka.

This study needs some future improvement. If we take a plant, more than one part can be used as medicines for different diseases. But we have considered only one part for each plant. In future we will include whole use of each plant which will be the complete system of herbs. More over the user interface also needs to be created.

References

[1]. Lt.Colonel K.R. Kirtikar F.L.S., I.M.S.`(Retired), Major B.D. Basu

[2]. M.R.C.S.(Eng), I.M.S.`(Retired) and An I.C.S. (Retired), ***Indian Medicinal Plants, Four volumes*** .

[3]. Zulazeze Sahri, Sharifalillah Nordin and Haryani Harun***, Malaysian Indigenous Herbs Knowledge Representation,*** Knowledge Management International Conference (KMICe) 2012, Johor Bahru, Malaysia, 4-6 July 2012, pp 253-259.

[4]. Sanjay Kumar Malik, Nupur Prakash, SAM Rizvi, ***Ontology design and development: Some aspects: An overview,*** **********

[5]. Vadivu. G and Waheeta Hopper, ***Ontology Mapping of Indian Medicinal Plants with Standardized Medical Terms,*** Journal of Computer Science 8 (9): 1576-1584, 2012, ISSN 1549-3636.

[6]. Graciela Brusa, Ma. Laura Caliusco and Omar Chiotti, ***A Process for Building a Domain Ontology: an Experience in Developing a Government Budgetary Ontology,*** Australian Ontology Workshop (AOW 2006), vol 72, Hobart, Australia.

[7]. Naveen Malviya, Nishchol Mishra and Santosh Sahu, ***Developing University Ontology Using Protégé OWL Tool: Process and Reasoning,*** International Journal of Scientific & Engineering Research Volume 2, Issue 9, September 2011, ISSN 2229-5518.

[8]. Priti Srinivas Sajja and Rajendra Akerkar, ***Knowledge-Based Systems for Development,*** Chapter 1, TMRF e-book, Advanced Knowledge Based Systems: Models, Applications & Research, Vol 1 pp 1-11, 2010.

[9]. Richard A.Smith, ***Designing A Cartographic Ontology for Use With Expert Systems,*** A Special joint symposium of ISPRS Technical Communication IV & AutoCarto in conjunction with ASPRS/CaGIS 2010 Fall Specialty Conference November 15-19, 2010 Orlando, Florida.

[10]. Watcharachai Wiriyasuttiwong and Walita Narkbuakaew and Members, ***Medical Knowledge-Based System for Diagnosis from Symptoms and signs,*** International Journal of Applied Biomedical Engineering VOL 2, No.1, 2009, pp 54-59.

[11]. Emhimed Alatrish, ***Comparison Some of Ontology Editors,*** Management Information Systems, Vol 8(2013), No-2, pp 018-024.

[12]. Natalya F. Noy, and Deborah L. McGuinness, ***Ontology Development 101: a Guide to Creating your First Ontology,*** http://protege.stanford.edu/publications/ ontology_development/ ontology101. Pdf.

[13]. Mathew Horridge, ***A Practical Guide to Build OWL Ontologies using PROTÉGÉ 4 and CO-ODE Tools, Edition 1.2,*** The University of Manchester.

[14]. Jane Mangold and Hilary Parkinson, ***Plant Identification Basics,*** A self-learning Resource from MSU Extension, MT201304AG New 9/13.

Agent-based Solution for Improving Abstracts

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Abstract

Writing abstracts in a comprehensive and meaningful manner is a challenge for any researcher. However, an abstract includes selected set of verbs, standard phrases and other good practices of structuring the contents. A research has been conducted to develop an automated solution for improving abstracts. This solution is based on multi agent systems technology and natural language processing together with ontology of commonly used verb phrases and other good practices. The system has been developed with nine agents, namely, coordination agent, parser agent, problem agent, solution agent, conclusion agent, content agent, synonym agent, improvement agent and restructure agent. These agents receive an abstract and interact with each other to reach consensus on the possible improvements to the abstract. For instance, problem agent and solution agent may agree on the proportion of respective contents within the abstract. The Stanford CoreNLP Natural Language Processing Toolkit has been used to develop parser and JADE has been used for development of the entire multi agent system. The system has been developed with JAVA to run on Windows. It has been incrementally tested, and shown interesting results related to improving abstracts.

1. Introduction

Over last six decades Artificial Intelligence (AI) techniques have shown unprecedented capacity to solve various complex real world problems which could not be solved otherwise [1]. In general, the real world systems encompass large numbers of interconnected entities operating in a distributed environment under unpredictable uncertainties [2]. Numerous Artificial Intelligence techniques including Natural Language Processing (NLP), Artificial Neural Networks (ANN), Genetic Algorithms (GA), Expert Systems (ES) and Multi Agent Systems have been developed over last sixty years. Increasing popularity and the penetration of AI technologies into wide spectrum of subject areas has resulted in generating smart solutions for complex real world problems [3]. More importantly, Multi Agent technology has shown its potential to generate emergent solutions which could not be generated by the individual level in systems. For instance, meaning of a sentence or text is an emergent feature generated over the worlds within the context. As such, we argue that Multi Agent technology can be used to implement computer-based understanding of texts in the area of NLP. It's a well known fact that NLP has been one of the least achieved area and striving to develop computer-based natural language understanding, machine translations, speech recognition since the inception of AI [4], [5]. This paper presents our multi agent-based NLP solution for generating suggestions for improving texts. The scope of the research has been restricted to handling abstracts in scientific documents.

2. Literature Review

Abstract gives an overview of the whole research. So, writing abstracts in a comprehensive and meaningful manner is a challenging task for any researcher. However an abstract includes a selected set of verbs, standard phrases and other good practices of structuring the contents. This research has been conducted to develop an automated assessment solution for improving abstracts. This solution is based on NLP together with commonly used verb phrases and other good practices. The system suggests improvements with relevant comments for the user to finalize the abstract. Hence, this system helps the writers to improve their abstracts in a comprehensive manner.

Lack of proper expertise limits the process of improving abstracts that leads to dissatisfaction of both the writers and the readers. Improving the abstracts has been seriously affected by the limitation of domain expertise. However an abstract includes limited set of verbs and standard phrases and other good practices of structuring the contents. This suggested solution is based on NLP together with commonly used verb phrases and other good practices to assist the writer to improve the abstracts.

Automated Essay Scoring (AES) is defined as the computer technology that evaluates and scores the written prose [6]. AES systems are developed to assist teachers in low-stakes classroom assessment as well as testing companies and states in large-scale high-stakes assessment [7]. They are mainly used to help overcome time limitations, cost, reliability, and generalizability issues in writing assessment [1], [8].

A number of studies have been conducted to assess the accuracy and reliability of the AES systems with respect to writing assessment [9]. The results of several AES studies reported high agreement rates between AES systems and human raters [2], [10].

AES systems have been criticized for lacking human interaction, vulnerability to cheating, and their need for a large corpus of sample text to train the system [11]. Despite its weaknesses, AES continues attracting the attention of public schools, universities, testing companies, researchers and educators [3], [12].

Estimates vary drastically as to the total number of spoken languages to date, something that is attributed to the difficulty of distinguishing between dialects and languages, and lies between five and eight thousand [13]. A language family consists of a set of languages that are related by descent from a common ancestor. It has been identified around four hundred different families, including isolates. English, a language belonging to the Indo-European family and the Germanic branch, is one of the most widely used [4].

Automated assessment focuses on automatically analyzing and assessing someone's competence. The field of automated assessment can be traced back to the early 1960s and emerged as a means to overcome issues arising with standardized assessment [14]. For example, it supports a faster assessment and distribution of results, an advantage for several reasons, such as instant feedback, not only at the level of an individual, but also to institutions wishing to address educational shortfalls promptly. Further advantages become more pronounced when it comes to marking extended texts, a task prone to an element of subjectivity. Automated systems guarantee the application of constant marking criteria, thus reducing inconsistency, which may arise in particular when more than one human examiner is employed. Often, implementations include more detailed feedback on the writers' writing abilities, thus facilitating self-assessment and self-tutoring [15]. Moreover, the potential of a reduced workload is becoming more attractive, especially in large-scale assessments. Standardized assessment entails an expensive and major logistical effort; automated assessment has the potential to drastically reduce time and costs for training and employing human scorers [8].

3. Technology Adapted

Artificial intelligence (AI) is defined as the science of making intelligent machines. AI has several applications including game playing, speech recognition, understanding natural languages, computer vision, and so on.

(i) Natural Language Processing (NLP)

NLP is considered to be one of the most challenging areas of AI. The research in NLP comprises a variety of fields including corpus-based methods, discourse methods, formal models, machine translation, natural language generation, and spoken-language understanding. There have been several empirical methods used in NLP. Previous methods (e.g., rationalist methods) required manual encoding of linguistic knowledge, which has proven to be difficult due to the complex nature of human language. Recent methods (e.g., empirical methods), however,

employ techniques that automatically extract linguistic knowledge from large-text corpora. In other words, empirical methods employ statistical or machine learning techniques to train the system on large amounts of authentic language data [1].

NLP is claimed to be a complex task to comprehend because it contains several levels of processing and subtasks. It has four categories of language tasks including speech recognition, syntactic analysis, discourse analysis, information extraction, and machine translation. Speech recognition focuses on diagramming a continuous speech signal into a sequence of known words. Syntactic analysis, on the other hand, determines the ways words are clustered into components like noun- and verb-phrases. Semantic analysis involves diagramming a sentence to a type of meaning representation such as a logical expression. Whereas discourse analysis focuses on how context impacts sentence interpretation and information [2].

(ii) Multi Agent System (MAS)

Agent software is a rapidly developing area of research. However, the overuse of the word 'agent' has tended to mask the fact that, in reality, there is a truly heterogeneous body of research being carried out under this banner [16].

Software agents have evolved from multi-agent systems, which in turn form one of three broad areas which fall under Distributed Artificial Intelligence, the other two being Distributed Problem Solving and Parallel AI. Hence, as with multi-agent systems, they inherit many of distributed artificial intelligence's motivations, goals and potential benefits. For example, software agents inherit distributed computing artificial intelligence's potential benefits including modularity, speed (due to parallelism) and reliability (due to redundancy). It also inherits AI features such as operation at the knowledge level, easier maintenance, reusability and platform independence [16], [17].

There are at least two reasons why it is so difficult to define precisely what agents are. Firstly, agent researchers do not 'own' this term in the same way as fuzzy logicians/AI researchers, for example, own the term 'fuzzy logic' - it is one that is used widely in everyday parlance as in travel agents, estate agents, etc. Secondly, even within the software fraternity, the word 'agent' is really an umbrella term for a heterogeneous body of research and development. The response of some agent researchers to this lack of definition has been to invent yet some more synonyms, and it is arguable whether these solve anything or just further add to the confusion. So we now have synonyms including knowbots (i.e. knowledge-based robots), softbots (software robot), taskbots (task-based robots), userbots, robots, personal agents, autonomous agents and personal assistants. To be fair, there are some good reasons for having such synonyms [16], [17], [18].

The hypothesis/goal of multi-agent systems is clear enough and has been proven in many multi-agent prototypes across the globe: creating a system that interconnects separately developed agents, thus enabling the ensemble to function beyond the capabilities of any singular agent in the set-up. Much important ground in such systems had been covered well before 1994, and it is truly a matter of debate how much real progress has been made since. Of course, there has been much consolidation of pre-1994 work. However, let us revisit the promises more closely whilst simultaneously interjecting with some of the reality [18], [19], [20].

Co-ordination is a central issue in software agent systems in particular, and in distributed artificial intelligence in general. However, it has also been studied by researchers in diverse disciplines in the social sciences, including organization theory, political science, social psychology, anthropology, law and sociology [20], [21], [22].

(iii) Ontology

Theories in AI fall into two broad categories: mechanism theories and content theories. Ontologies are content theories about the sorts of objects, properties of objects, and relations between objects that are possible in a specified domain of knowledge. They provide potential

terms for describing our knowledge about the domain [23].

Most research on ontologies focuses on what one might characterize as domain factual knowledge, because knowledge of that type is particularly useful in natural-language understanding. There is another class of ontologies that are important in Knowledge Based Systems one that helps in sharing knowledge about reasoning strategies or problem solving methods [24].

In AI, knowledge in computer systems is thought of as something that is explicitly represented and operated on by inference processes. However, that is an overly narrow view. All information systems traffic in knowledge. Any software that does anything useful cannot be written without a commitment to a model of the relevant world to entities, properties, and relations in that world. Data structures and procedures implicitly or explicitly make commitments to domain ontology. It is common to ask whether a payroll system "knows" about the new tax law, or whether a database system "knows" about employee salaries. Information retrieval systems, digital libraries, integration of heterogeneous information sources, and Internet search engines need domain ontologies to organize information and direct the search processes. For example, a search engine has categories and subcategories that help organize the search. The search engine community commonly refers to these categories and subcategories as ontologies [25].

Object oriented design of software systems similarly depends on appropriate domain ontology. Objects, their attributes, and their procedures more or less mirror aspects of the domain that is relevant to the application. Object systems representing a useful analysis of a domain can often be reused for a different application program. Object systems and ontologies emphasize different aspects, but we anticipate that over time convergence between these technologies will increase. As information systems model large knowledge domains, domain ontologies will become as important in general software systems as in many areas of AI [26].

4. Proposed Solution

Preliminary editing of a document in a specified domain can be automated with NLP techniques and MAS. We propose a novel solution to automate improving abstracts by using NLP and MAS.

(i) Inputs to System

Agent-based Solution for Improving Abstracts (ASIA) has been designed to accept multiple inputs coming from different entities for improving the abstracts. System would accept the abstracts as the inputs to the system.

(ii) Outputs from the System

The output is the pre edited abstract with comments for improvements.

(iii) Process

Having entered the inputs, the system will use NLP and MAS to generate the output. In this process two major types of processes are defined. Knowledge required to operate these processes are stored in a common domain. This has knowledge required for editing of documents together with the context specified knowledge. For example morphology, syntax and pragmatic are included from the language perspective. Further context based knowledge such as problem, solution, conclusion are also available.

(iv) Features

Following features are available in the system: minimal resource usage, online availability and the development cost is marginal.

5. Design

This section critically discusses about the overview of the proposed design.

In the first step when an abstract is input to the proposed system, a parser agent would act on it.

After it has gone through the parser agent, other agents of the multi agent system would act on it to analyze the content & balance and suggest restructuring & improvements. This multi agent system would argue about the problem, solution & conclusion.

In the second step title of the research paper is checked against the abstract and look for the overall match of the abstract to the title. In the third step proposed system checks whether the Problem, Solution & Conclusion is there in the abstract.

Then in the fourth step proposed system checks the content for accuracy. The proposed system got ontology of keywords which should and shouldn't be used in an abstract. The proposed system automatically checks whether the content have those keywords which should be there in an abstract and the content does not contain the keywords that should not be there in an abstract. So, the system checks whether the necessity is there in the abstract.

Then the system checks whether the balance between the problem, solution & conclusion exists. As an example the abstract should discuss about the problem less than the solution and the solution should be explained much more than the problem. Also the system assures that the references, citation and further work is not there in the abstract.

Then in the fifth step the proposed system makes suggestions for improvements and editing of the document using the ontology. This includes rephrasing, rewording, restructuring and revising for improving the abstract. The system would suggest synonyms which are much more suitable to be used in the abstract.

(i) Multi Agent Swarm Intelligence

When an abstract has been input to this system it would be feed into a parser agent which is the first step in the system. After going through the parser agent, multi agent swarm of agents would act on it to analyze the content and balance and suggest restructuring and improvements. The agents in this multi agent swarm discuss about the problem, solution and conclusion and provide suggestions to improve the abstract.

(ii) Checking the overall match between the Title and the Abstract

In this step title of the research paper is matched against the abstract and look for the overall match of the abstract to the title. Here the system analyzes the title of the research paper against the content of the abstract and check whether the abstract discuss about the topic mentioned in the title and gives the feedback.

(iii) Check whether the Problem, Solution & Conclusion is mentioned in the Abstract

In this step proposed system checks whether the Problem, Solution & Conclusion is there in the abstract. System looks for the words like issue, address, proposes, approach, methodology, etc… and identify whether the abstract consists of the problem, solution & conclusion and gives the feedback whether those sections are included in the abstract.

(iv) Check the Accuracy of the Content of the Abstract

In the fourth step proposed system checks the content for accuracy. The proposed system got ontology of keywords which should and shouldn't be used in an abstract. The proposed system automatically checks whether the content have those keywords which should be there in an abstract and the content haven't those keywords which shouldn't be there in an abstract. So, the system checks whether the necessity is there in the abstract.

Then the system checks whether the balance between the problem, solution & conclusion is there. As an example the abstract should discuss about the problem less than the solution and the solution should be explained much more than the problem. Also the system assures that the references, citation and further work is not there in the abstract.

(v) Suggestions for Improvements

The last step of the proposed system makes suggestions for improvements and editing of the document using its ontology. This includes rephrasing, rewording, restructuring and revising for improving the abstract. The system would suggest synonyms which are much more suitable to be used in the abstract.

(vi) Ontology

Ontology which consists of keywords that should and shouldn't be there in an abstract would be maintained to be accessed by the multi agent swarm to check whether the content

of the abstract have those keywords that should be used in the abstracts and the content of the abstract haven't those keywords that shouldn't be used in abstracts.

So, necessity of the content of the abstract can be checked and assured. Also, this ontology would consist of the synonyms for suggesting rewording, verbs, standard phrases and other good practices for structuring the contents of the abstracts.

6. Implementation

This section critically discusses about the overview of the proposed implementation of the ASIA. This implementation of the proposed ASIA is based on the NLP and MAS technology together with commonly used verb phrases and other good practices as ontology.

The system has been developed with a MAS of nine agents, namely, coordination agent, parser agent, problem agent, solution agent, conclusion agent, content agent, synonym agent, improvement agent and restructure agent. This multi agent system of nine agents interacts with each other and deliberates to reach consensus regarding a solution.

The system has been developed with JAVA to run on Windows platform. This proposed solution has been incrementally tested for results and has been evaluated on Windows environment. However as JAVA is platform independent, this proposed implementation of ASIA can be easily ported to other platforms as well.

The Stanford CoreNLP Natural Language Processing Toolkit which is a very powerful API for NLP has been mainly used to develop the parser agent and JADE which is a very popular framework for agent development has been used for development of the entire MAS.

(i) Coordination Agent and Parser Agent

The coordination agent initiates and coordinates the entire process. The parser agent identifies syntactic information of each sentence and prepares the contents of the abstract for further analysis. These agents would interact with other agents of the multi agents system developed in this proposed implementation to reach consensus regarding the solution. The coordination agent and parser agent will use their ontologies for deliberating with other agents.

(ii) Problem Agent

The problem agent ensures whether the research problem has been stated in the early part of the abstract and its proportion within the abstract. This agent would interact with other agents of the multi agents system developed in this proposed implementation to reach consensus regarding the solution in terms of the proportion of problem section within the abstract. The problem agent would use it's ontology for deliberating with other agents.

(iii) Solution Agent

The solution agent checks for the contents in terms of concepts such as hypothesis, methodology, approach, design, implementation, methods, theoretical framework, technology, hardware, software, and sampling. This agent would interact with other agents of the multi agents system developed in this proposed implementation to reach consensus regarding the solution in terms of the proportion of solution section within the abstract. The solution agent would use it's ontology for deliberating with other agents.

(iv) Conclusion Agent

The conclusion agent searches for concepts such as testing, evaluation, data analysis and statistical significance. This agent would interact with other agents of the MAS developed in this proposed implementation to reach consensus regarding the solution in terms of the proportion of conclusion section within the abstract. The conclusion agent would use it's ontology for deliberating with other agents.

(v) Content Agent, Synonym Agent, Improvement Agent and Restructure Agent

The content, synonym, improvement and restructure agents are responsible to offer guidelines to modify and improve the abstract. These agents would interact with other agents of the multi agents system developed in this proposed implementation to reach consensus regarding the solution in terms of the synonyms

and rephrasing the abstract. The content, synonym, improvement and restructure agents would use it's ontologies for deliberating with other agents.

(vi) Multi Agent System

The agents in this multi agent system of the proposed implementation of ASIA would interact with each other and deliberate to reach consensus regarding a solution. As an example, problem agent, solution agent and conclusion agent may agree on the proportion of respective contents within the abstract. Each agent has its own ontology for deliberating with other agents in this multi agent system.

(vii) Testing

The proposed implementation of ASIA has been incrementally tested on Windows environment, and shown interesting results related to checking for completeness of the abstract in terms of required materials and suggestion for improvements.

(viii) The Stanford CoreNLP Natural Language Processing Toolkit

Stanford CoreNLP provides a set of natural language analysis tools which can take raw text input and give the base forms of words, their parts of speech, whether they are names of companies, people, etc., normalize dates, times, and numeric quantities, and mark up the structure of sentences in terms of phrases and word dependencies, indicate which noun phrases refer to the same entities, indicate sentiment, etc.

Stanford CoreNLP is an integrated framework. Its goal is to make it very easy to apply a bunch of linguistic analysis tools to a piece of text. Starting from plain text, developer can run all the tools on it with just two lines of code. It is designed to be highly flexible and extensible. With a single option developer can change which tools should be enabled and which should be disabled. The analyses provide the foundational building blocks for higher-level and domain-specific text understanding applications.

Stanford CoreNLP integrates many of their NLP tools, including the part-of-speech (POS) tagger, the named entity recognizer (NER), the parser, the coreference resolution system, the sentiment analysis, and the bootstrapped pattern learning tools. The basic distribution provides model files for the analysis of English, but the engine is compatible with models for other languages.

(ix) JADE Framework

JAVA Agent DEvelopment Framework is an open source platform for peer-to-peer agent based applications. JADE (Java Agent DEvelopment Framework) is a software Framework fully implemented in the Java language. It simplifies the implementation of multi-agent systems through a middle-ware that complies with the FIPA specifications and through a set of graphical tools that support the debugging and deployment phases.

A JADE-based system can be distributed across machines (which not even need to share the same OS) and the configuration can be controlled via a remote GUI. The configuration can be even changed at run-time by moving agents from one machine to another, as and when required. JADE is completely implemented in Java language and the minimal system requirement is the version 5 of JAVA (the run time environment or the JDK).

Besides the agent abstraction, JADE provides a simple yet powerful task execution and composition model, peer to peer agent communication based on the asynchronous message passing paradigm, a yellow pages service supporting publish subscribe discovery mechanism and many other advanced features that facilitates the development of a distributed system.

Due to the contribution of the LEAP project, ad hoc versions of JADE exist designed to deploy JADE agents transparently on different Java-oriented environments such as Android devices and J2ME-CLDC MIDP 1.0 devices.

Furthermore suitable configurations can be specified to run JADE agents in networks characterized by partial connectivity including NAT and firewalls as well as intermittent coverage and IP-address changes.

JADE is a free software and is distributed by Telecom Italia, the copyright holder, in open source under the terms and conditions of the LGPL (Lesser General Public License Version 2) license. Besides the JADE Team, however, a fairly large Community of developers gathered around the JADE Framework in these years.

7. Evaluation

Overall system has been evaluated by using real world scenarios to verify the accuracy and the performances of the ASIA system with the help of the human experts. As this proposed solution deals with more subjective areas, evaluation is much more needed to verify the solutions provided in this system. Many evaluations were carried out on the various parts of the system with the help of the human domain experts.

Overall match between the title and the abstract has been evaluated by entering sample abstracts and their titles which have been taken from real world well recognized research papers to the system. System has been evaluated by entering the titles of it's and title of other research papers against a particular abstract. Overall matching scores have been compared to evaluate the title abstract matching accuracy.

The ASIA system has been evaluated for its accuracy in checking whether the problem is stated in the abstract by inserting abstracts from the real world well recognized research papers with and without the problem statement parts. The system has been able to correctly recognize whether the problem is stated in the abstract or not.

The ASIA system has been evaluated for its accuracy in checking whether the solution is stated in the abstract by inserting abstracts from the real world well recognized research papers with and without the solution statement parts. The system has been able to correctly recognize whether the solution is stated in the abstract or not.

The ASIA system has been evaluated for its accuracy in checking whether the conclusion is stated in the abstract by inserting abstracts from the real world well recognized research papers with and without the conclusion statement parts. The system has been able to correctly recognize whether the conclusion is stated in the abstract or not.

The ASIA system has been evaluated for its accuracy in checking the balance between the problem, solution and conclusion parts stated in the abstract by inserting abstracts from the real world well recognized research papers with and without the correct balance in between the problem, solution & conclusion parts. The system has been able to correctly recognize whether the correct balance is there in the abstract in between the problem, solution & conclusion or not.

The ASIA system has been evaluated for its accuracy in checking the content in the abstract by inserting the abstracts from the real world well recognized research papers with and without the correct usage of suitable words in the content. The system has been able to correctly recognize whether the correct usage of suitable words is there in the abstract content or not.

The ASIA system has been evaluated for its accuracy in suggesting the synonyms for the words used in the abstract by inserting the abstracts from the real world well recognized research papers. The system has been able to correctly suggest the synonyms for the words used in the abstract.

The ASIA system has been evaluated for its accuracy in suggesting the improvements for the content in the abstract by inserting the abstracts from the real world well recognized research papers. The system has been able to correctly suggest the improvements for the content in the abstract in terms of spellings and grammar.

The ASIA system has been evaluated for its accuracy in suggesting the restructurings for the content in the abstract by inserting the abstracts from the real world well recognized research papers. The system has been able to correctly suggest the restructurings for the content in the abstract in terms of balance and the richness of the problem, solution and conclusion statements.

8. Conclusion and Future Work

Research has been breakdown into multiple objectives. Main objective has been achieved by critically studying the improving abstracts with a view to identify current practices and issues. Next challenge was to critically analyze the existing solutions in ASIA with the view to define the research problem and possible technology. After it was achieved then next step was in depth study about improving abstracts and its applications. Then moved to design and implement the ASIA.

Finally evaluated the improving abstracts using the real world scenario to test and verify the accuracy and the performance of the proposed system. Every research opens the paths and leads to few more other new researches and this research is also no difference. Since Artificial Intelligence techniques are new to improving the abstracts, this research will open lot of paths for new other researches. Even though this research has delivered all of its main objectives, there are lots of other areas that identified to improve by accuracy and as well as performance wise.

Agents in the Multi Agent System can be improved and the respective ontologies can be improved for increasing the accuracy and deriving the better performance. Also the user friendliness of the system can be improved to increase the end user satisfaction.

MAS in the proposed solution for improving the abstracts can be improved by increasing the capabilities of the remaining Agents in the MAS as well as introducing new Agents to the MAS. Agents' features could be sharpened by adding much more logic and increasing the communication among the Agents.

Proposed solution for improving the abstracts can be improved by improving the ontologies of the respective agents. Much more knowledge can be added to the remaining ontologies to improve the capabilities of those agents. So, those agents can make better decisions and can make better contributions for improving abstracts.

User friendliness of the proposed solution for improving abstracts can be improved by adding much more user friendly features to the current system. By improving the user friendliness of the system, proposed solution can be improved significantly. Graphical User Interface of the current system can be improved for a better communication with the end users and can provide much more attractiveness to the end users.

References

[1] Helen Yannakoudakis, "Automated assessment of English-learner writing", Technical Report Number 842, University of Cambridge, Computer Laboratory, October 2013

[2] SemireDikli, "An Overview of Automated Scoring of Essays", The Journal of Technology, Learning, and Assessment Volume 5, Number 1, August 2006

[3] Salvatore Valenti, Francesca Neri and Alessandro Cucchiarelli, "An Overview of Current Research on Automated Essay Grading", Journal of Information Technology Education, Volume 2, 2003

[4] FeliceDell'Orletta, MartijnWieling, Andrea Cimino, Giulia Venturi and SimonettaMontemagni, "Assessing the Readability of Sentences: Which Corpora and Features?", Proceedings of the Ninth Workshop on Innovative Use of NLP for Building Educational Applications , pages 163–173, Baltimore, Maryland USA, June 26, 2014, Association for Computational Linguistics

[5] Jill Burstein, Martin Chodorow and Claudia Leacock, "Automated Essay Evaluation: The Criterion Online Writing Service", AI Magazine Volume 25 Number 3 (2004), American Association for Artificial Intelligence

[6] Rachele De Felice, Stephen G. Pulman, "Automatic detection of preposition errors in learner writing", Oxford University Computing Laboratory, 19 March 2008

[7] Ryu Iida, Takenobu Tokunaga, "Building a Corpus of Manually Revised Texts from Discourse Perspective", Graduate School of Information Science and Engineering, Tokyo Institute of Technology

[8] Siddhartha Ghosh, "Online Automated Essay Grading System as a Web Based Learning (WBL) Tool in Engineering Education", Chapter 5, G. Narayanamma Institute of Technology and Science, India

[9] Elizabeth Salesky, Wade Shen "Exploiting Morphological, Grammatical, and Semantic Correlates for Improved Text Difficulty Assessment", Proceedings of the Ninth Workshop on Innovative Use of NLP for Building Educational Applications, pages 155–162, Baltimore, Maryland USA, June 26, 2014. Association for Computational Linguistics

[10] Attali, Y. and Burstein, J. (2006). Automated essay scoring with e-Rater v.2.0. Journal of Technology, Learning, and Assessment, 4(3):1 – 30.

[11] Landauer, T. K., Laham, D., and Foltz, P. W. (2003). Automated scoring and annotation of essays with the Intelligent Essay Assessor. In Shermis, M. and Burstein, J. C., editors, Automated essay scoring: A cross-disciplinary perspective, pages 87 - 112.

[12] Briscoe, T., Medlock, B., and Andersen, ¬. E. (2010). Automated assessment of ESOL free text examinations. Technical Report UCAM-CL-TR-

790, University of Cambridge, Computer Laboratory, http://www.cl.cam.ac.uk/techreports/UCAM-CL-TR-790.pdf.

[13] Rudner, L. and Liang, T. (2002). Automated essay scoring using Bayes' theorem. The Journal of Technology, Learning and Assessment, 1(2):3 - 21.

[14] Higgins, D., Burstein, J., and Attali, Y. (2006). Identifying off-topic student essays without topic-specific training data. Natural Language Engineering, 12(2):145 - 159.

[15] Lonsdale, D. and Strong-Krause, D. (2003). Automated rating of ESL essays. In Proceedings of the HLT-NAACL 2003 workshop on Building Educational Applications Using Natural Language Processing, pages 61 - 67. ACL.

[16] Nwana, H. (1996), "Software Agents: An Overview", The Knowledge Engineering Review, 11 (3), 205-244.

[17] Nwana, H &Azarmi, N. (eds) (1997), "Software Agent and Soft Computing: towards enhancing machine intelligence", Lecture Notes in Artificial Intelligence 1198, Springer-Verlag, New York.

[18] Hyacinth S. Nwana and Divine T. Ndumu, "A Perspective on Software Agents Research".

[19] Nwana, H. S. (1990), "Intelligent Tutoring Systems: An Overview", Artificial Intelligence Review 4 (4).

[20] Nwana, H. S., Ndumu, D. T., Lee, L. C. & Collis, J. C. (1999), "ZEUS: A Toolkit for Building Distributed Multi-Agent Systems", Applied Artificial Intelligence Journal 13 (1/2), 129-185.

[21] Nwana, H.S., Lee, L. Jennings, N.R. (1996), "Coordination in software agent systems", BT Technology Journal, 14(4) (1996) 79–88.

[22] Nwana. H. S. &Ndumu, D. T. (1999), (eds)., Special Issue of Applied Artificial Intelligence Journal 13 (1/2).

[23] B. Chandrasekaran and John R. Josephson, Ohio State University, V. Richard Benjamins, University of Amsterdam, "What Are Ontologies, and Why Do We Need Them?", IEEE INTELLIGENT SYSTEMS, JANUARY/FEBRUARY 1999

[24] N. Guarino and R. Poli, "The Role of Ontology in the Information Technology," Int'l J. Human-Computer Studies, Vol. 43, Nos. 5/6, Nov.-Dec. 1995, pp. 623–965.

[25] G. Van Heijst, A.T. Schreiber, and B.J. Wielinga, "Using Explicit Ontologies in KBS Development," Int'l J. Human-Computer Studies, Vol. 46, Nos. 2/3, Feb.-Mar. 1997, pp. 183–292.

[26] M. Uschold and A. Tate, "Putting Ontologies to Use," Knowledge Eng. Rev., Vol. 13, No. 1, Mar. 1998, pp. 1–3.

Question Matching Technique to Find Answers

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Abstract

In today's business world, there are lots of knowledge systems and users need to find answers from existing knowledge bases. Due to the complexity of the systems and fat contents of them, it is difficult for users to find appropriate answers to their questions. Knowledge bases can be configured to mapped answers to questions. When end user enters a question, using natural language processing and text mining techniques, the question is matched with the existing question in the question bank in the knowledge base and matched answer and any other related contents (if exists) are provided to the end user. Proposed technique was evaluated with Sri Lankan 1978 constitution knowledge base and it was found that many questions can be matched with higher accuracy.

***Index Terms* — Natural Language Processing, NLP, Text Mining, Term Frequency, TF-IDF, Cosine Distance, SoundEX.**

1. Introduction

There exists large number of knowledge bases in different domains and they have gathered lot of information over the years. Users frequently need to query those contents. Since most of these knowledge bases are unstructured and complex, retrieving relevant information is complex and will be a tedious process.

As there are no structural techniques to retrieve contents from large and complex knowledge bases, most users implement simple text retrieval techniques. This will return lot of documents and they might not be even matching the users' intended requests. So users might need to read almost all the documents and users have to verify whether the content is what s/he was looking for. Some users may implement technique like Microsoft Full Text Search [MSDN, 2012] which provides some features to retrieve documents with higher accuracy than a simple text search.

Every knowledge base has frequently asked questions a.k.a. FAQs. Therefore, if system can matched the user entered question to this FAQs, it can provide the answers to end users where in the knowledge base each question is linked to one or more answers. Sometimes FAQ can be linked to different data sets depending on the domain. In case of Sri Lankan legal domain, questions can be linked to legal cases, incidents and constitution contents. So when the question is matched, relevant cases, incidents and constitution content will be retrieved addition to the answer to the question. In this type of complexity, it will be difficult to use simple text matching technique.

Another issue with the simple text matching technique is that, there can be similar words. For example, user might be searching for a word called "amend", but there can be questions which has words like "amended", "amendment" or "amending" which should also be matched. However, with the simple text matching technique, those documents will not be matched and those documents will be ignored from the search.

Also, there are similar words which are relevant to each domain. For example, in Sri Lankan legal domain, 1978 constitution, President is referred as head of the state and head of the cabinet. So when users are raising questions, they may state about President but the question contains head of state which needs to be matched.

Also, in the knowledge bases, there are lot of key words are used. Users may raise a question stating PM which is an abbreviation for Prime Minister. Questions might be set up with Prime Minister and those questions needs to be mapped when user enters question with one or more abbreviations.

2. Current Work

In the research paper about Ontology-bases Question Answering System, architecture was proposed [Lee S, Ryu P., Choi K., 2006] to answer questions and it shows the path for ontology lookup for four types (concept

completion, example, enablement, and goal orientation). For each of the type, they have observed diverse search paths. For example, after searching a class for questioned entity, three kinds of paths are possible. The path selection is determined by query type. In determining search path, we should also consider the type of questioned entity (class/instance). It can be seen that the path for concept completion type is divided with two paths according to the results of class/instance discrimination. For the proposed question answer mechanism, questions should be arranged in a stucture. However, not all knowledge bases can be arranged in the given structure. Therefore, this method is more suitable for simple knwoledge bases not suited for legal domain queries.

In another short research paper named, Rich Lexical Knowledge based Q&A System for Ubiquitous Knowledge Service, it describes a simple domain specific (rice) architecture for ontological question answering system [Kawtrakul A. & Thunkijjanukij A, 2009].

Proposed question answering system is based on three sources of knowledge which interact:

- Lexical data and in particular lexical semantics and lexical inference.
- The domain data as represented by the rich conceptual functions, i.e. Rice Ontology.
- Some general purpose knowledge, useful for answering questions.

This is the closest architecture for the proposed research in this paper. However, evaluation results are not available with this research paper.

In another research paper, question and answering system was designed for Dinning Ontology [Palaniappan L., Sambasiva Rao N., 2010]. Proposed architecture of dining ontology as domain. User query will pass through annotator of named entities, then queries will be checked whether it is synchronized, after test by reasoner, the answer will be searched in the text pool and it is retrieved. Instead of going to database query, template process queries faster. Thus reusability is enhanced. In this research, another important mechanism is to match the questions in the Ontology with the question that users are entering.

Research paper by Jing Yu and et. al. titled Similarity Measure of Test Question Based on Ontology and Vector Space Model (VSM) is to identify same question from question bank [Yu J., Li D & et. al, 2014]. VSM is a common method for measuring text questions similarity in massive item bank system proposed by Salton in 1970s [Galton S. & Buckley G., 1988]. It is relatively legacy algorithm which was used in measuring text similarity. Though this algorithm is easy to be applied, it has ignored the relations among words in the documents and only uses words frequency. In this research paper, better solution was proposed.

Also, in another research [Asanka PPGD, 2013], cosine distance was used to identify closely matched documents using Term Frequence – Inverse Document Frequency (TF-IDF) technique. In this research paper, matrix was provided to find closely matching document using cosine distance. In the matrix, red cells indicate closely matching documents while white cells are the documents which are loosely matching documents. In this research, simple terms are used to match documents, hence the error rate is high in the proposed technique. However, the question matching technique is some what similar to doucument mapping technique which is helpful for this research.

3. Design

Question matching is done in two steps. First, all questions in the ontology needs to be analyzed and second step is to match the user question with the existing questions.

In the first step, there are three sub steps. Initial step will capture global terms for all questions with the frequency. String Representation and Soundex is used to capture global terms. In Natural Language Processing (NLP) , there are different text representation and depending on the text representation analysis is different [Zhai C., 2015]. String text representation is the most general representation and it is robust. Hence for this research, String representation is used.

There can be similar terms such as amend, amendable, amending, amendment, amendments with different formations. SOUNDEX algorithm is identified to find the similarities of similar words.

SOUNDEX is a phonetic algorithm for indexing names by sound as pronounce in English. The goal is for homophones to be encoded to the same representation, so that they can be matched despite minor differences in spelling [Poole D, 2012]. The algorithm mainly encodes consonants and a vowel will not be encoded unless it is the first letter. SOUNDEX is the most widely known of all phonetic algorithms [Poole D, 2014].

SOUNDEX function is used in Microsoft SQL Server 2014 [MSDN, SOUNDEX, 2012] to identify the SOUNDEX value of each term.

In the Global Terms capturing step, all the terms are captured and SOUNDEX value or each term is stored. While capturing Global Terms, frequent terms like, ‘a’,

'and', 'the', 'on', 'an', are ignored to improve the performance.

Next step is to find out, terms for each question which is called term lookup. There are several methods to calculate term frequencies such us simple count, log vector, 0/1 bit vector and BM25. For this research, word count method is selected as term frequency method.

Third step is to calculate TF-IDF for each question. Calculating Cosine Distance for documents using Term frequencies may not be accurate as there can be common terms across the documents. Therefore, Inverse document frequency is introduced. TF-IDF can be used to calculate the distance between the documents.

These three steps are shown in the Figure 1, where SQL Server Intergration Services (SSIS) was used.

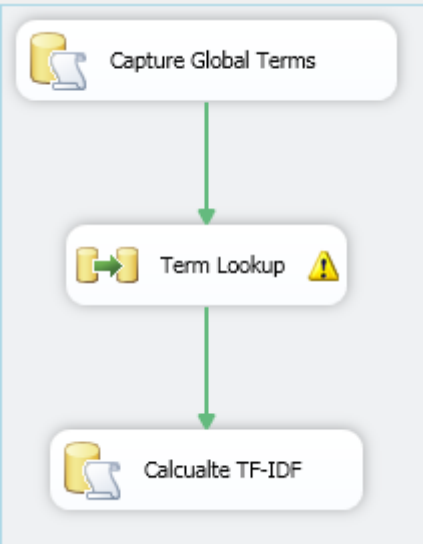

Figure 1. Calculate TF-IDF for Existing Questions in the Question Bank

For all the questions, TF-IDF is calculated before and saved in the database to improve performance of the searching mechanism.

Next part is, matching the user entered question with the question bank. When a user enters a question, first it needs to be checked for spelling. Though there is no special spell checker included, with the use of SOUNDEX error with wrong spelling is minimised.

There are several ways to calculate distance between two objects. There are Euclidean distance, Cosine distance, City-block (Manhattan) distance, Chebychev distance and Mahalanobis distance [Hair J.F. et. al., 2012]. Usually, Cosine Distance method is used to calculate the distance between two documents [Hand D. et al, 2007]. Apart from above distance measures, there are other measures like Chi-square, Lift, AllConf, Jaccard, Cosine, Kulczynski, MaxConf etc [Han J., 2015].

Question type also needs to be considered. There can be same terms used in multiple questions. Only the difference between those questions are objective of the question. That is which, what, how many etc. Every question in the question bank will have a question type. So when user enters the question, apart from the term matching, there need to have a question type matching as well.

Since there are two rankings, one ranking from terms and another ranking from question type. Question type ranking and term ranking is multiply to obtain the final ranking.

Final Ranking = Term Ranking * Question Type Ranking^ ^{n}

n - is decided by after carrying out few experiments and best n value is 0.5.

Typically, abbreviations and similar words are used as said before. For example, most people uses MP for Members of Parliament and PM for Prime Minister. Also, users use similar words. For example, President is Head of State and Head of the Cabinet. So when users enter President or Head of State both times it is referring to the same person or object. So Ontology is used to store those information which is described in implementation section later.

4. Implementation

Microsoft SQL Server 2014 was used to store data and Microsfot SQL Server Intergration Services (SSIS) was used to extract data. Proper indexes are used to enhace performance.

Frequently used words, abbrivations and similar terms are saved in the database. Since those are stored in the database, it can be easily modifed or new content can be added to those tables when required which has improved the usability.

5. Evaluation

Question matching can be divided into three areas such as normal question matching, questions with abbreviations and questions with similar words.

Evaluation was done by entering legal domain questions which are relevant to Sri Lanka. 1978 Sri Lankan constitution was used for the purpose of evaluation. Following scenarios were identified to evaluate the proposed system. Retrived questions are manually verified

to evaluate whether it is relevant. Most relevent questions are listed at the top in all cases.

Scenario 1: How to amend the constitution

When the above question is entered, following are the matching questions returned from the proposed system.

Questions Returned for Scenario 1

Question	**Is it Relevant?**
Who approves amendments to the constitution?	Yes
Which provisions are not amendable?	Yes
What are the details of the amendment proposal process?	Yes
How is the head of government selected?	No
What are the details for the amendment approval process?	Yes
How is the head of state selected?	No
How many executives are specified in the constitution?	No
What proportion of the vote is needed to approve a constitutional amendment?	Yes
How are members of the second chamber selected?	No
Does the constitution provide for at least one procedure for amending the constitution?	Yes

Out of the ten questions returned, seven questions are relevant to the question in senario 1 and no questions in the question bank are missed in the list. This means that, there is 70% of accuracy whereas the ranking is concerned, 67% (37 / 55) is the ranking relevancy. 37 is the total ranking for the correct questions while 55 is the total ranking for all the questions returned. Total ranking is calculated by considering the return order of the returned questions. For example, for the if the first question is relevent 10 ranking points were given.

Scenario 2: How to remove Members of Parliament?

When the above question is raised, only one question is retrieved which is "Are there provisions for dismissing members of parliament?". So there is 100% matching both with the number of questions and the ranking is concerned.

Scenario 3: How to remove MPs?

Scenario 3 is the same question as Scenario 2 with introducing on MPs instead of members of parliament. However, same question is returned. So it also has the 100% accuracy.

Scenario 4: What are the provisions to remove head of state?

Following are the questions returned for the above question.

Questions Returned for Scenario 4

Question	**Is it Relevant**
Are there provisions for dismissing the head of state?	Yes
Who can propose a dismissal of the head of state?	Yes
What are the details of the process to remove judges?	No
Who are the electors for the head of state?	No
Are there provisions for dismissing the head of government?	Yes
Who may remove the chief of the central bank?	No

Out of the six questions returned, three questions are relevant to the question and no questions in the question bank are not missing in the list. This means there is 50% of accuracy whereas the ranking is concerned and it has 62% (13 / 21) is the relevency ranking.

Scenario 5: What are the provisions to remove President?

Following are the questions returned for the above question. This scenario has similar words as of scenario 4.

Questions Returned for Scenario 5

Question	**Is it Relevant**
Are there provisions for dismissing the head of state?	Yes
Who can propose a dismissal of the head of state?	Yes
What are the details of the process to remove judges?	No
Who are the electors for the head of state?	No
Are there provisions for dismissing the head of government?	Yes

Out of the five questions returned, three questions are relevant to the question and no questions in the question bank was missed in the list. This means there is 60% of accuracy whereas the ranking is concerned it is 67 % (10 / 15) ranking relevancy.
When all the scenarios are considered ranking relevancy is at least 60% and in some scenarios it is 100 %.

6. Conclusion and Further Work

In the current system, user question needs to be matched to the question to get the answer and other related contents. This research can be further improved by providing an option to automatically find answer even if there is no matching question.
There are additional features introduced with SOUNDEX function like spell checking and also system has the capability of matching with abbreviations and equal terms. However, system does not have the ability of matching questions semantically. If that can be adopted, the system, system will be further enhanced. For example, when user enters query which includes, “person” system should be able to understand that citizen and person are equal in semantic. Currently only the words in local ontology will be matched, but system should be extended to get semantic words from defined third party Ontologies.
In this research, it was able to find a mechanism to map questions in the question bank to the user entered questions. For the selected sample scenarios, ranking relevancy is at least than 60% and in some scenarios it is 100 %.

References

[1] Asanka PPGD., “Finding Similar Text Files using Text Mining”, 8th IEEE ICCSE 2013 Colombo.

[2] Galton S., Buckley G., “Term-weighting approaches in automation text retrieval”, Information Processing and Management, vol. 24, no. 5, pp. 513-523, 1988.

[3] Hair J.F., Black W. C., Babin B. J., Anderson R. E. and Tatham R. L., in Multivariate Data Analysis, New Delhi, Pearson Education in South Asia, 2012, p. 599.

[4] Han J., Pattern Discovery in Data Mining, University of Illinois at Urbana-Champaign, Course Period 2015-Feb-09 – 2015-Mar-08.

[5] Hand D., Mannila H. and Smyth P., "Retrival by Content," in Principles of Data Mining, New Delhi, Prentice Hall of India Private Limited, 2007, p. 456–464.

[6] Kawtrakul A., Thunkijjanukij A., Khantonthong N., “Rich Lexical Knowledge based Q&A System for Ubiquitous Knowledge Service”., Department of Computer Engineering, Kasetsart University, Bankok, 2009,

[7] Lee S, Ryu P., Choi K., “Ontology-based Question Answering System”, Korea Advanced Institute of Science and Technology., 2006.

[8] Microsoft Development Network, Query with Full-Text Search, MSDN, *https://msdn.microsoft.com/en-us/library/ms142583.aspx,* Accessed on 2014-12-04.

[9] Microsoft Development Network, *SOUNDEX (Transact-SQL), MSDN,* https://msdn.microsoft.com/en-us/library/ms187384.aspx?f=255&MSPPError=-2147217396, *Accessed on 2015-02-20.*

[10] Palaniappan L., Sambasiva Rao N., “An Ontology-based Question Answering Method with the use of Query Template”, International Journal of Computer Applications (0975 – 8887), Volume 9– No.9, November 2010.

[11] Poole D., “Soundex - Experiments with SQL CLR”, SQLServerCentral.com, http://www.sqlservercentral.com/articles/Programming/101836/, 2013/09/12, Accessed on 2015/06/12.

[12] Poole D., “Soundex - Experiments with SQLCLR Part 2”, SQLServerCentral.com,

http://www.sqlservercentral.com/articles/soundex/120628/,, 2014/12/30, Accessed on 2015/06/12.

[13] Russel M.A., Whiz-Bang A., "Introduction to TF-IDF" in Mining the Social Web, New Delhi, O'Reilly Media, Inc., 2011, p. 201.

[14] Yu J., Li D., Hou J., Liu Y., Zhaoying Yang, "Similarity Measure of Test Question Based on Ontology and VSM", The Open Automation and Control Systems Journal 2014, 6, pp 262-267.

[15] Zhai C., Week 1: NLP, Text Representation, and Word Association Mining, Text Mining and Analytics, Department of Computer Science, University of Illinois at Urbana-Champaign., www.coursera.org., 2015.

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