SAEE - A Swarm of Agents for English Editing

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***Abstract* - In this knowledge economy, writing comprehensively is a chief value-producing activity. Natural Language editing in an automated environment is a complex task and due to this complexity, current automated tools face the limitation of perfectly editing a given write up considering both syntactic and semantic accuracy. Therefore, there is a need of evolutionary, adaptive, autonomous and dynamic approach for natural language editing.**

As the solution 'A Swarm of Agents for English Editing' (SAEE) is a multi agent based approach for evolutionary English editing. This system comprises a swarm of agents with spell checking agents, noun agents, verb agents, determiner agents, style agents and manager agent where each agent activates upon a request, executes and kills them at the end of the task. Unlike traditional editing software this system is based on negotiations among different agents rather than instruction driven. In this system English editing task involves interaction among different agents who take care of different aspects of a sentence structure such as noun, verb and determiners. These agents together with the manager agent negotiate with each others to generate an agreeable output. A common message space is used to enable the communication and thus negotiations among different agents in the swarm to come up with a commonly agreeable edited text.

1. INTRODUCTION TO A SWARM OF AGENTS FOR ENGLISH EDITING (SAEE)

Natural languages evolve with human beings for centuries and they are still evolving. It evolves from gestures, mummers, words and to sophisticated and advance modern languages. In parallel with communication abilities of human beings, the written skills also evolved. There is a great psychology behind the language manipulation capabilities of human beings which in turns control the speaking and written abilities.

Fodor's modularity of mind concept explains, human mind is composed of separate innate structures which cause evolutionary development of functional properties such as language and thoughts, volition and cognition, learning and remembering and sensation and perception [1]. This view is influenced by Noam Chomsky's concept of a universal, generative grammar [4]. This universal feature implies the existence of a language acquisition structure in the brain. This device is postulated to be autonomous and specialized for learning languages rapidly [4]. This module has given humans the ability to acquire the capacity to perceive, produce and use words to understand and communicate. This capacity involves the picking up of diverse capacities including syntax, phonetics, and an extensive vocabulary. We can visualize this mechanism inside language acquisition structure as a cooperative work of a set of experts in different aspects of language constructions, such as grammar checking, spelling checking, rephrasing…etc. These experts have some templates with them which they utilize when they engage in language manipulation (Construction and editing) activities. It is notable that, these experts communicate with each other and as well with other modules inside the brain, share knowledge, and keep expanding their capacity to learn things and intelligence emerge within them as a consequence of interaction. On the other hand these experts acquire and store knowledge as the person reads things, from the social relationships of the person and by visualizing things. In this manner human brain can construct or edit a write up, with the help of these experts living inside their brains. Throughout our lifetime we are tend to proof read or edit our writings with the help of experts before we use them in actual scenarios. The process of proof reading includes many sub tasks such as checking for grammatical errors, spellings, word order, contextual dependencies, rephrasing, semantics…etc which can be divided in to three major categories as morphology, syntax and semantics of a language.

Proof reading by a set of experts of the language and the specific subject area, is the most appropriate way for preparing a perfect write-up. Due to the difficulties in finding the experts always and as a circumstance of technological advancements many applications have been developed to automate the process of proof reading. But still a human expert can proof read far better than the automated tools. Though a machine can process hundreds of thousands of data in few seconds, still human experts can precisely edit a write-up when compared with computers. This is because of the indigenous structure in human brain which helps a person to manipulate a language uniquely.

Since English is a natural language it has a complex construction, based on the diversity of meaning for words and expressions according to the context. Human brain is structured in such a way that it can handle these complexities in natural languages. Though there are many comprehensive editing tools for computer languages, still there are no tools for computers to edit natural languages precisely. Software programs are not prepared to handle these ambiguities since the implementation of different aspects of editing are isolated from each others. No communication or collaboration is enabled within these functionalities. There is no approach to handle natural languages as it is naturally done inside human brain, which is the most effective approach.

SAEE (A Swarm of Agents for English Editing), the solution presents a system where, an English sentence is checked for different syntax and semantic aspects in an evolutionary manner based on negotiation between agents.

The proposed solution is basically based on multi agent architecture and Natural Language Processing (NLP) concepts. In a multi agent environment, different agents expert in their fields interact with each other by the means of communication, negotiation and coordination to come up with a solution for a given issue. Multi-agent systems can be used to solve problems which are difficult or impossible for an individual agent or monolithic system to solve. Most importantly, in a multi agent environment the agents (experts) handles the sub tasks under the main task and come up with the most effective and efficient solution for a problem as the experts contribute to the final solutions in their own ways. There are six types of agents named as, spelling agents, noun agents, verb agents, determiner agents, style agents and manager agent in this solution. Main idea behind is; when an input sentence is given, the agents in the swarm communicate with each others to negotiate for an agreeable edited output.

2. RESEARCHES AND AVAILABLE TOOLS FOR NATURAL LANGUAGE EDITING

Natural language editing is a very crucial task in our daily routines. Therefore from the very beginning of the evolution of computers, word processors or text editors with language editing capabilities were adopted. With the evolution of the computers, these language editing capabilities in word processors also evolve. In the modern world, computers can manipulate thousands of records in a second but still the human proof readers are far better than those automatic editing tools. There are many attempts to reduce this gap between human proof readers and automatic proof reading tools. Following is a briefing of available tools for natural language editing and research going on in the subject area.

2.1 Language editing capabilities of current word processors

When we talk of automatic natural language editing, the major tools exist in the current context for this purpose are word processors. Word Processing is not a new concept and was one of the earliest applications of the personal computers in office productivity. English editing functionality of current word processors mainly deals with "spell checking" (checks against wordlists), "grammar checking" (checks for what seem to be simple grammar errors), and a "thesaurus" function (finds words with similar or opposite meanings). Microsoft office package, writer in Open Office package, AbiWord [7] are some widely used word processors which provides English language editing capabilities.

Spell Checkers

Spell checking is one of the vital aspect in English language editing and almost every word processor, other desktop applications such as email client...etc and web based systems includes spell checkers. Simple spell checkers operate on individual words by comparing each of them against the contents of a dictionary, possibly performing stemming on the word.

Grammar Checkers

The automated grammar checking for a natural language is almost a tedious task due to the complexities in natural languages. The early grammar checkers checked for the misuse of phrases and the overuse of phrases (clinched) in a text. To achieve this goal they stored many phrases considered by the experts as poor writings, and a list of alternative phrases for each of them. Then the checking program would simply break text into sentences, check for any matches in the phrase dictionary, and flag suspect phrases and show an alternative. These checkers would typically flag doubled words, doubled punctuation, some capitalization errors, and other simple grammar mistakes.
A grammar checker will find each sentence in a text, look up each word in the dictionary, and then attempt to parse the sentence into a form that matches a grammar. Using various rules, the program can then detect various errors, such as agreement in tense, number, word order, and so on.

Thesaurus

Most modern word processors entangle a thesaurus which plays a major role in English editing. A built-in thesaurus allows searching for synonyms without leaving the word processor. The program should maintain a list of synonyms which are then used to suggest alternative words for a given particular word.

Rephrasing

Rephrasing mainly deals with the semantics of a sentence rather than the syntax and this is basically detecting some stylistic problems with the text. For example, heavy use of passive voice is not considered a good writing style. When a sentence carries no grammatical or spelling mistakes, it is possible to detect passive voice, and rewrite the sentence in proper form.

2.2. Enhancing word processors with Natural Language processing capabilities

Natural language processing (NLP) and text mining techniques can deliver automated analysis support, but they are often not integrated into commonly used desktop clients, such as word processors. But researches have been conducted to use NLP capabilities in language editing tasks. A plug-in has been proposed for the OpenOffice.org word processor Writer that allows accessing any kind of NLP analysis service mediated through a service-oriented architecture [6]. Once those NLP analysis services are accessed, they can be used to enhance the language editing capabilities of the word processor such as automatic

summarization, index generation, language rephrasing and many more.

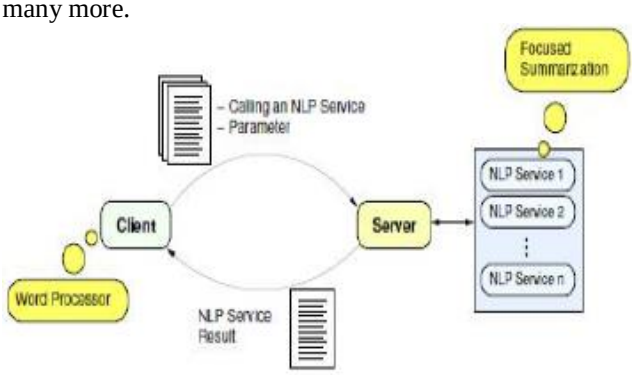

Figure 1: Invoking NLP services directly from a user's word processor

In this research a plug-in created based on an existing service-oriented architecture, for Writer allows to dynamically find, parameterize, and execute language services. This attempt is not concerned with the development of new NLP services, but rather investigates how any existing service can be integrated into an end user's word processor. Though this research is aimed at utilizing the power of NLP techniques in language editing, it has not mentioned how to utilize the services for editing purposes once they are successfully accessed.

2.3. A Semantic Analyzer for English Sentences

Researchers have been conducted in the area of computational linguistics to make the computers understand the semantics of a sentence and then utilize that understanding for the appropriate manipulation of that sentence. This is quite easily done inside human brain with less effort. But for a computer like device, it is a tedious task to fully understand the semantics of a natural language. If a natural language is to be understood in any nontrivial sense by a computer (e.g., if a computer is to accept English statements and questions, perform syntactic and semantic analyses, answer questions, paraphrase statements and/or generate statements and questions in English), there must exist some representation of knowledge of the relations that generally hold among events in the world as it is perceived by humans. Robert F. Simmons et al at System Development Corporation in Santa Monica, California has proposed a cognitive model, to serve as a basis for understanding natural language, having the capability of representing the verbal events, the syntactic relations that hold among them, and their mapping onto the cognitive events they stand for [5]. This mapping from symbolic events of a language onto cognitive events defines a semantic system.

This cognitive model consists of objects, events and relations. In this model an event is defined as an object or an event – relation – event (E-R_E) triplet [5]. An object is represented as a node in a graph and a relation can be either an object or an event. Any perception, fact or happening can be represented as an event and this event can further be expanded to a nested structure of E-R-E triplets. The entire structure of a person's knowledge can be expressed as events according to this cognitive model.

"Meaning" of a sentence in this system is defined as the complete set of relations that link an event to other events. Two events are exactly equivalent in meaning only if they have exactly the same set of relational connections to exactly the same set of events. Two English statements are equivalent in meaning either if their cognitive representation in event structure is identical, or if one can be transformed to the other by a set of meaning-preserving transformations (e.g., inference rules) in the system. The major challenge in this system is to convert text strings into cognitive structure. Though this model is not specifically proposed for a language editing tasks like rephrasing, it can be used for rephrasing in language editing.

D. *Ontological Semantic Analysis and Difficult Reference*

Marjorie McShane et al at Institute of language and Information Technologies, University of Maryland Baltimore County has proposed a model which presents a blend of processing of semantics and use of reference resolution for semantic analysis of a sentence [3]. Reference resolution is linking of referential text strings (words and phrases) to each other with little or no connection to semantics. The proposed analyzer in this research paper takes raw text as input and carries out its tokenization, and morphological, syntactic, semantic and pragmatic analysis to yield text meaning representations (TMRs). One an English sentence is given the system analyze the semantics using the following features of the proposed system,

- Language independent ontology which carries, over 8000 concepts.
- Lexicon for each language processed, whose entries contain, among other information, syntactic and semantic zones (linked through special variables) as well as meaning-procedures.
- Real-world facts represented as numbered instances of ontological concepts in fact repository. Act as an intelligent memory. The relationships between instances of objects and events are stored in the fact repository

The core of semantic analysis is creating an unambiguous, language independent representation of the meaning of text. The system is intended to store information extracted from TMRs in the fact repository then query the fact repository as needed for semantic analysis.

Maryland Virtual Patient is a Multi agent system for automating certain facets of medical training [2, 3]. The environment contains a network of human and software agents, at whose core are a virtual patient – a knowledge based model of a person with a disease. It is intended in decision making about healthcare and lifestyle, and the experiencing and remembering of interceptive events. This multi agent system uses the above mentioned system proposed by Mc Shane et al for the communication between the human agents, various software agents and virtual patients. Input sentences for this system are the dialogues with the doctor. Background knowledge that must be leveraged is the knowledge stored in the lexicon, ontology and the patient's long-term memory of assertions, also called its fact repository.

Following is an actual TMR for a set of questions for the virtual patient [2]. The example illustrates how the patient analyzes the semantics of the input sentences. Have you been coughing? Do you find yourself coughing? Do you experience any coughing? Do you ever experience coughing? Do you have a cough? Any coughing? Coughing? All of these questions ask whether or not the patient has the symptom ontologically described as the event called COUGH. The extended TMR for this set of questions is,

(REQUEST-INFO-1
(THEME MODALITY-1.VALUE))
(MODALITY-1
(TYPE EPISTEMIC)
(SCOPE ASPECT-1))
(ASPECT-1
(ITERATION MULTIPLE)
(SCOPE COUGH-1))
(COUGH-1
(EXPERIENCER HUMAN-1)
(TIME
(FIND-INTERVAL (FIND-ANCHOR-TIME)
(FIND-INTERVAL-LENGTH) BEFORE)))

Though this concept is proposed for medical diagnosis, this can be used in language editing tasks, especially for sentence rephrasing.

3. EVOLUTIONARY APPROACH FOR ENGLISH EDITING

In considering the complex nature of natural language editing in an automated environment, SAEE propose a Multi Agent System (MAS) approach for automated natural language editing. Agents in a MAS can interact, collaborate and compete to achieve a common goal for a complex scenario. The approach for using swarm intelligence in English editing is also inspired by the remarkable features of multi agent technology such as reliability, efficiency, extensibility and robustness…etc.

In a MAS, individual agents can analyze, filter and retrieve information within their proximity and inform the others towards a better solution. Another special feature of MAS is that we can introduce small agents attached to legacy systems and enable interaction between agents where agents act as wrappers to those legacy systems. There are natural language processing systems that have been developed using Multi Agent Technology [2][3], and most of them are aimed at semantic understanding of the sentences. SAEE is a novel approach for English editing which is enlivened by the power of Multi Agent System technology.

Natural language editing cannot be addressed as a sequential process but as a complex situation where different aspects of editing as spell checking, grammar checking and semantic handling works together for an accurate and rich output.

The proposed MAS consist of spelling agents, verb agents, noun agents, determiner agents, style agents and manager agent. The request resource model with the message space and ontology is used to model this Multi Agent System. There is a single request agent and many resources agents. Ontology consists of English dictionaries, rules for grammar analysis, and rules for style analysis.

In SAEE approach, Spell checking dictionaries and sentence parsers are reused instead of developing them from the scratch. The agents in the MAS provide an agent wrapper for these reusable spell checkers and sentence parsers.

In editing a given English sentence agents work together for a most suitable output as there can be several possible outputs. For example the sentence "Sn is shining" has incorrect spelling. Therefore once the sentence is presented in the message space, spelling agent detects there is an incorrect spelling in the sentence and come up with a list of suggestions such as "sin, son, sun, Sr, an, in, on, so". In such scenario, it is difficult to decide the appropriate word to replace the incorrect. To resolve the problem, the agents in the swarm start communicating over the message space to decide on the word to be replaced. For example, noun agent analyzes the two adjacent sentences, and detects the noun sun is used in one or in both sentences. Therefore word 'sun' is selected from the suggestion list to replace 'Sn '. But still there exists the possibility for semantic ambiguity.

It is important to note that agents do not make the decisions in isolation, but communicate with other agents, and take their opinions into account altogether with their own capabilities to come up with the final solution. Therefore in this scenario, agents communicate over the message space to make negotiations for an agreeable output.

4. DESIGNING A SWARM OF AGENTS FOR ENGLISH EDITING

This chapter describes the details of the design and the analysis of proposed solution. SAEE is designed according to the request, resource model in MAS domain together with a powerful ontology and a comprehensive

message space. In this scenario there is a single request and many resource agents to facilitate that request. These resources agents collaboratively support to edit a given English sentences in an evolutionary manner. There are five types of agents in this MAS as spelling agents, verb agents, grammar agents, determiner agents, style agents and manager agent. Manager agent monitors the whole process and is responsible in generating the final edited text, considering the suggestions of different agents.

Message space facilitates the communication in the means of negotiation between different agents. The ontology consists of an English dictionary, grammar rules and rules for styles which are written in XML and Part of Speech tags information. As well there are spelling analyzers, noun analyzers, verb analyzers, determiner analyzers and style analyzers to support agents to use the knowledge in the ontology.

Brief description of the design of each module is given below. Figure 2 depicts the high level architecture of the system.

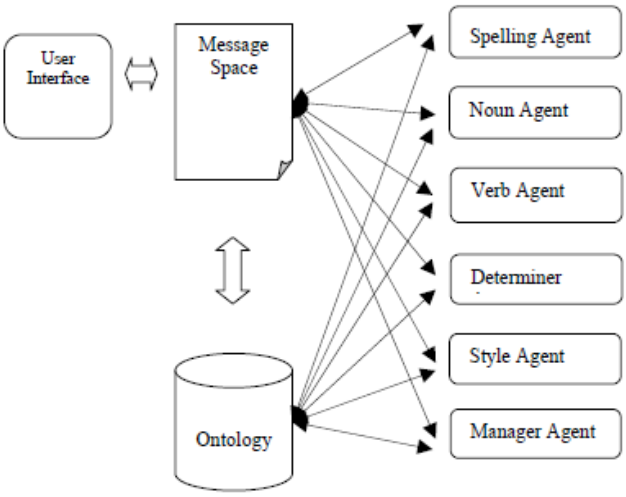

Figure 2: High level architecture of SAEE

4.1 Spell Checker Agent

Spell checker agents use the spelling analyzer and the dictionary in the ontology to detect incorrect spelling and generate the suggestions. Once the input is written in the message space, spelling agents are automatically created for each sentence and using the spelling analyzer and the dictionaries available in the ontology spelling errors are detected and suggestions are made. Then the results are written back to the message space. Once their task is completed, spelling agents get terminated.

4.2 Noun Agent

Each sentence is passed to the sentence parsing tool (OpenNLP) in the ontology to tokenize and parse the sentence and to generate Part of Speech (POS) tag for each token. For the noun token, noun agents get created. Noun agents use the rules related to the nouns in the ontology and noun analyzer to detect the incorrect usage of grammar and make the necessary suggestions. Noun agents write the partial results to the message space. Once their task is completed, noun agents get terminated.

4.3 Verb Agent

Verb agent is designed similarly as noun agent. Upon a request verb agents get created for every sentence and they uses the knowledge in the ontology via verb analyzer to detect any incorrect usage of verbs and to make the suggestions. Once their work is over, verb agents get terminated.

4.4 Determiner Agent

Determiner agent is designed similarly as noun agent and provides the similar functionalities for determiners and articles of a sentence. They use the determiner analyzer and the rules in the ontology to detect any errors related to determiners and to make the necessary suggestions. The suggestions are written to the message space and agents get terminated once their tasks are accomplished.

4.5 Style Agent

Style agent is also designed similarly as agents mentioned above. Style agents detect the bad style usages in a given input and suggest the necessary corrections. They use the style analyzer and the knowledge in the ontology to detect bad styles such as redundant phrases and collocations. Style agents write the necessary suggestions to the message space and get terminated once their task is over.

4.6 Manager Agent

Manager agent is the main agent in the system and plays a vital role. Once the other agents write different suggestions to the message space, manager agent makes the necessary negotiation among different suggestions and generates the most appropriate output. For example, for a particular sentence, noun agent may suggest a correction and verb agent may make different suggestions, both might be syntactically correct. Therefore manager agent considers the structure (nouns and verbs) of the adjacent sentences and makes the final output. Manager agent get initialized and started at the system initialization time and get terminated once the overall processing is done and the output is written to the output area.

5 IMPLEMENTATION OF SAEE

As mentioned in the design section, this system is mainly designed to be implemented using Multi Agent based technology. Agents are created using the JADE [12] framework which complies with FIPA (Foundation for Intelligent Physical Agents) standards. The overall system architecture is developed using J2SE platform. For

splitting the sentences in a given paragraph, generate tokens for each sentence, to generate Part of Speech (POS) tags for each token and to parse the sentence using TreebankParser, OpenNLP tools are used. OpenNLP is a research program which provides open source Natural Language Processing (NLP) tools. Agent communication is enabled via a message space, which is an XML file.

Agent based development assists the system to be autonomous (activate with little user intervention), reactive (respond on requests), proactive (still works even without a request), rational (do the most appropriate thing), intelligent and to enable communication among swarm of agents to come up with the best possible solution.

This system uses six agents to accomplish English editing in an evolutionary manner. Once the input is given, manager agent split it to separate sentences and write them in the message space. These sentences are tokenized, and for each token POS tags are created. Then agents get created for each noun, verb and determiner POS tag. Agents start processing the sentences using the analyzers and the resource stored in the ontology as dictionaries and rules. Then agents write the partial results of their processing to the message space and upon completion of their tasks get terminated. Manager agent monitors the whole scenario, and after considering the suggestions of different agents makes the negotiation for an agreeable edited text. For example,

'She is walking. I has some flowers in her bag. She stop at a shop to buy some milk.'

is an input to the system. While processing is going on, noun agent writes to the message space that second sentence should be corrected as 'I have some flowers in her bag.' and third sentence as 'She stops at a shop to buy some milk.' Simultaneously verb agent suggests that 'has' in second sentence should be used with third person pronouns such as she, he or it. Manager agent reads both suggestions and analyzes the two adjacent sentences to the second sentence. Since the pronoun used in adjacent sentences is 'she', the manager agent negotiates among verb and noun agents to agree on 'She has some flowers in her bag' than 'I have some flowers in her bag.'

6 EVALUATION OF SAEE

Evaluation of SAEE is based on two criterions. The system is tested with the natural language editing capabilities of the existing editing tools and the actual human proof readers. A set of input sentences are checked with the existing editing tools like MS Word, Open Office and as well with human proof readers. These results are compared with the results of SAEE for evaluation.

7 CONCLUSIONS AND FURTHER WORK

This paper discusses a Multi Agent based system for evolutionary English editing to address the limitations, complexities and challenges in handling natural languages in an automated environment. Agents in the MAS use the knowledge in the ontology to process the input and negotiate with each other via the common message space to achieve the common goal; to come up with the best edited text. Agents work as a team to gain a common goal and the overall performance goes beyond the capability level of individual agents.

There are several future enhancements that can be performed to improve the usability and other functional and nonfunctional performance of the system. As the most important enhancement, the ontology of the system can be widen and enriched. Currently more than two hundred grammar rules and styles are supported by the system and we can add more and more rules and styles to the ontology to enhance the quality of the output. On the other hand the number of agents can also be increased to handle more complex scenarios.

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