

LITERATURE REVIEW

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TERRIFIC DISPOSITION: PROCEDURAL STORYLINE GENERATION

A brief literature review of natural language processing and fuzzy logic, and their potential applications in relation to the final year project of Justin Alexander Shanks (P15225881) for the Computer Games Programming BSc course at De Montfort University.

INTRODUCTION

The proposed project revolves around a procedurally generated storyline for a computer game using elements of fuzzy logic and natural language processing in its implementation. As a result, the main subjects approached for this literature review are those of fuzzy logic, natural language processing, and natural language generation.

The literature reviewed, although from a variety of sources, were included as they had what was deemed as relevant and quality information regarding the subjects for review. The relevancy was determined by whether or not the literature directly explored fuzzy logic or natural language processing, whereas the quality was found through the inclusion of technical journals, conference proceedings, or documentation for APIs for the relevant subjects.

As a result of these standards, the sources selected have been deemed sufficiently reliable. It should be noted that although the journal and conference documents have been acquired from peer reviewed sources, the two sets of API documentation have not. As a result, they may be deemed as the least reliable due to the lack of academic rigor being applied to them. However, seeing as the APIs in question are extensive in their reference to natural language processing theory and models, they can still be deemed sufficiently acceptable for the purposes of this literature review.

These parameters resulted in narrowing down the extensive literature to a few sources that are directly related and hold the most relevant information for the task at hand.

FUZZY LOGIC CLASSIFICATION

As a prelude to this section of the literature review, it should be noted that the focus of this review centred around classification implementations of fuzzy logic, as opposed to control implementations. This decision was made in order to narrow down the scope of related literature so that it would be more directly related to the language processing review.

FUZZY LOGIC BASIC

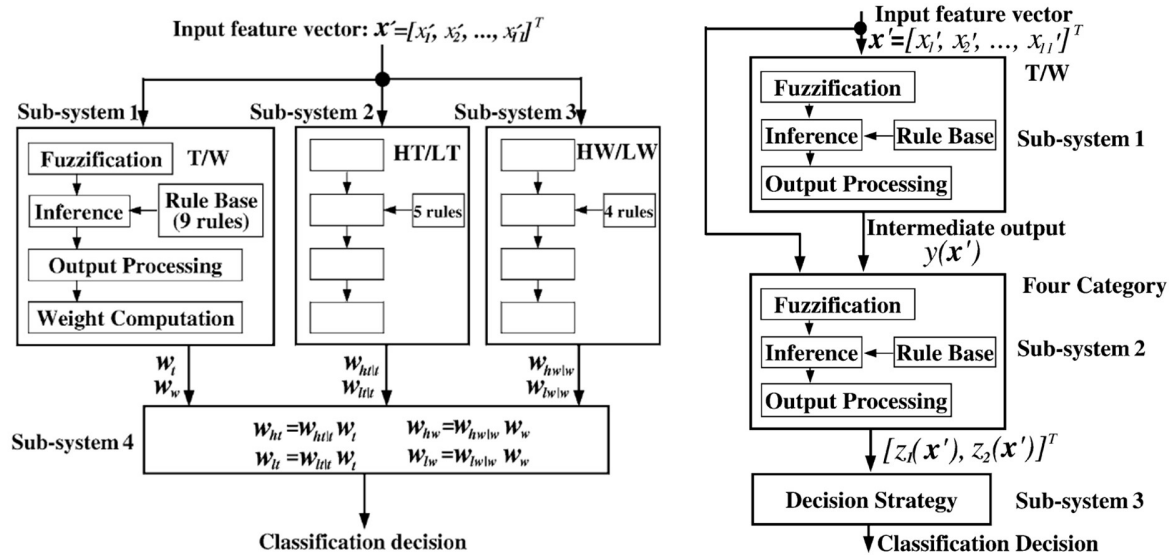


Figure 1a (Wu & Mendel, 2007, p. 63) and Figure 1b (Wu & Mendel, 2007, p. 65)

The referenced *Classification of Battlefield Ground Vehicles Using Acoustic Features and Fuzzy Logic Rule-Based Classifiers* demonstrates the necessity to put data through a layer of fuzzification in order to properly apply a rule based system to eventually classify the input in question. (Wu & Mendel, 2007, p. 65) Although this uses a series of fuzzy inference subsystems in conjunction with a decision strategy, it does demonstrate that a proposed classification system should contain a comprehensive set of rules with which to filter data.

These systems are typically referred to as “Fuzzy Logic Rule-Based Systems” (Wu & Mendel, 2007, p. 60) and have a common set of components. A fuzzifier that converts the input to fuzzy sets designed to be processed by later components, such as the fuzzy inference engine and a rule-base that work together to figure out the degree of membership that the fuzzy input have within the possible classifications, and lastly an output processor, or defuzzifier. This is designed to return a crisp output after the fuzzy inference engine has processed the required data. (Wu & Mendel, 2007, p. 60)

Although the referenced text is not oriented towards text processing or generation, it is important to keep in mind that the basics of fuzzy logic classifiers are capable of being applied to several subjects. What follows is a more text oriented implementation of fuzzy logic.

TEXT ORIENTED FUZZY LOGIC

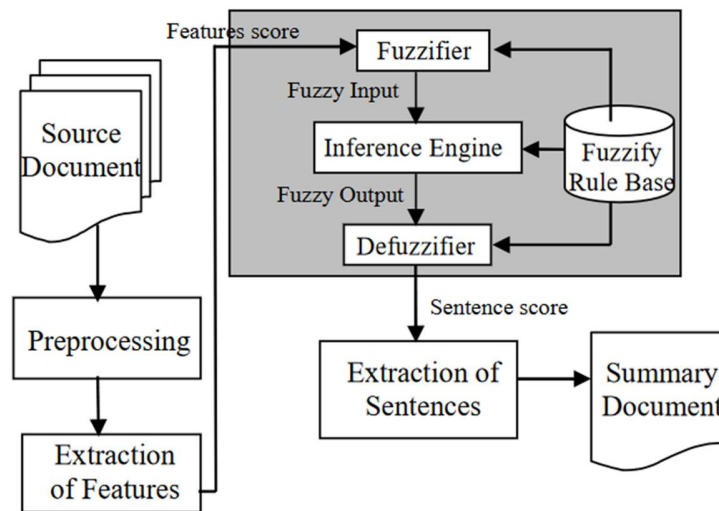


Figure 2 (Suanmali, et al., 2009, p. 4)

As with Wu & Mendel 2007, *Fuzzy Logic Based Method for Improving Text Summarization* concerns itself with the use of fuzzy inference systems in order to classify a given input. However, the task at hand becomes the use of sentence extraction techniques in order to summarize a given text, and in order to do this it is necessary to classify extracted sentences by how much information they contain in order to omit the superfluous sentences. (Suanmali, et al., 2009, p. 1)

Although a comprehensive rule base was used for the task of classification, some such rules pertained to the position of the sentence in the text, the similarity of this sentence with others, and the prevalence of specific terms across the text. (Suanmali, et al., 2009, pp. 2-3) This was done in an attempt to identify which sentences contain important terms, are presented first, and that seem to be reiterated by the remaining text, as Suanmali et al found these as the most important features when attempting to summarize a text through extraction-based techniques, rather than abstraction-based. (Suanmali, et al., 2009, p. 3)

Suanmali et al posit a success in the use of a fuzzy inference engine as their results showed “that the extraction of 20% of sentences from the source document can be [just] as informative” (Suanmali, et al., 2009, pp. 4-5) as their fuzzy inference system was able to outperform other tested systems using a set of metrics acronymed ROGUE. (Suanmali, et al., 2009, p. 5)

In concluding, with the use of natural language processing techniques in order to tokenize a given set of sentences, it was possible to effectively use a fuzzy logic system to classify the sentences by overall usefulness in text summarization. As a result, what will follow is an exploration of natural language analysis and relevant techniques.

NATURAL LANGUAGE ANALYSIS

Although primarily focused on natural language processing, it was deemed necessary at an early stage of literature research that the coverage of natural language generation was important. As a result, this section of the literature review will consist of both processing and generation, further elaboration of this decision and its importance will come later.

NATURAL LANGUAGE PROCESSING (NLP)

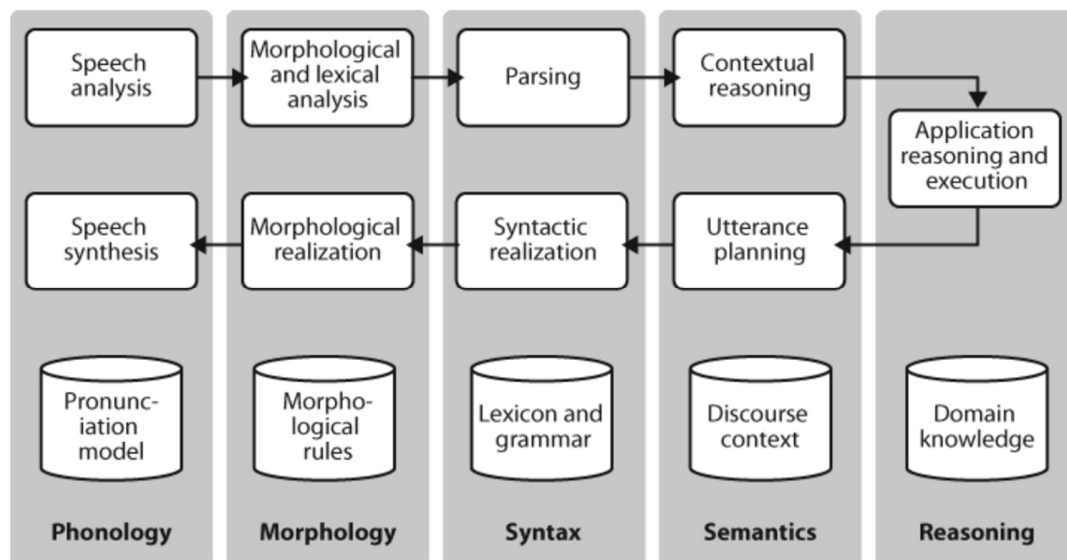


Figure 3 (Bird, et al., 2009, p. 32)

Bird et al 2009 presents a simplistic processing pipeline for a spoken dialogue system, wherein there are five primary stages of processing including; phonology, morphology, syntax, semantics, and reasoning. (Bird, et al., 2009, pp. 31-32) However, for the purposes of this project the subject of phonological processing will not be covered as it concerns itself only with spoken dialogue systems, and not with other implementations of natural language processing.

What remains are; morphology being the relation between words of the same language, syntax being the rules that define a language's sentence structure, semantics being the different meanings behind a word, and reasoning being the application of the sentence within a given context.

These are important stages of processing within natural language processing, as they are necessary in order to better reduce the possible abstraction of a given text. An example of this importance would be the need to reduce the ambiguity of words within a given text, which can be done by keeping track of common terms and their position in a given sentence. (Bird, et al., 2009, pp. 27-28) This is would pertain to the realms of syntax and semantic processing, as they deal with sentence structure and word meaning, and would be necessary in order to better understand the text given in for processing. A solution to this problem would be the provision of grammar rules, a lexicon of words, and a set context, but a scalable solution also exists wherein machine learning is used to learn as interactions increase. (Bird, et al., 2009, pp. 31-32)

If the former solution is undertaken, it would not necessarily require a hardcoding of these corpora, or body of text, as the NLP pipeline is well designed to extract the necessary context from provided texts. This would be done through the provision of a text, such as a book or transcript, that is within the same as the desired

context and can therefore be tokenised and further processed in order to develop a vocabulary of relevant terms. (Bird, et al., 2009, pp. 86-87)

This stage of tokenisation is a part of normalization, in which text is segmented into different components in order to properly filter out duplicate terms and even terms that are heavily related, if indeed necessary. (Bird, et al., 2009, pp. 109-112) This allows for a shorter set of words, and word segments, to be processed and even helps identify terms that are regularly presented in a text. The latter being a stage of lemmatization where the headword of multiple terms are identified, a headword being the root or base class of the term, through an example of morphological analysis.

At first this may result in an over appreciation of words such as “the” due to their prevalence in a text, this would be when part-of-speech tagging (POS tagging) comes into effect, this being the use of a statistical model in order to predict the classification of word within a given sentence structure, such as a noun, verb, or adjective. (Explosion AI, 2016, p. Linguistic Features)

What follows is a combination of dependency parsing, and named entities, which use the previous stage of tokenisation and POS tagging in order to confirm the lemmatization stage and then to identify multiple words used contiguously to refer to a named entity. (Explosion AI, 2016, p. Linguistic Features) These named entities can then be considered as nouns, albeit improper, or can be merely used as important terms in the definition of the application’s context.

The final stage of reasoning is more a developer-heavy task as it is the creation of an application capable of using the processed information for the desired solution. What follows is an exploration of how natural language processing techniques come into the generation of text, or dialogue, as well as a brief expansion on the relevancy of corpora or corpus within NLP.

NATURAL LANGUAGE GENERATION (NLG)

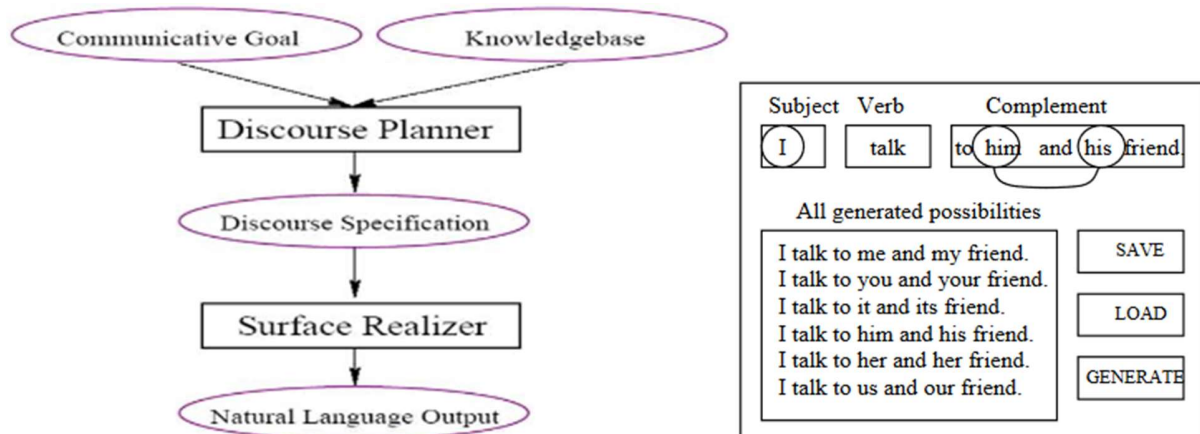


Figure 4a (Caropreso, et al., 2009, p. 2) and Figure 4b (Caropreso, et al., 2009, p. 5)

Two common implementations of NLG are Template-Based and Rule-Based, or linguistic. (Oh & Rudnicky, 2000, p. 27) The former refers to the use of pre-built phrase templates in order to generate expected dialogue with few abstractions whereas the latter involves the use grammar rules to generate dialogue capable of abstraction. (Bauer, et al., 2015, p. 4) These two implementations have related limitations; templates allow for faster dialogue generation but rely heavily on their construction quality, and rules allow for better quality dialogue generation but has a higher processing requirement. (Oh & Rudnicky, 2000, p. 27)

Template-based generation seems best suited for small applications that have a series of expected interactions with the user, although even with seemingly small applications the number of templates

required to ensure a fluid dialogue with the user increases greatly. (Oh & Rudnicky, 2000, p. 27) This may require a great amount of time not only in creating the templates, but also maintaining templates in a dynamic system that may be subject to change.

Rule-based generation, on the other hand, is best for complex applications with a large amount of abstraction or nuance expected with user interaction. However, the complexity of the rule-based system becomes increasingly more apparent as multiple-languages, dialects, and grammar contentions arise. (Bauer, et al., 2015, pp. 3-4) Seeing as grammar and syntax rules may change greatly between different languages, and may even be linked with other elements of language such as having German syntax linked with semantics. (Bauer, et al., 2015, p. 4)

The referenced *Stochastic language generation for spoken dialogue systems* identifies many of the features and limitations of these two implementations and as such posits that a corpus-based approach may be beneficial to certain applications. (Oh & Rudnicky, 2000, p. 27) As the name implies, as corpus is the Latin root for body and corpse, a body of text compiled by experts in a given field is analysed. Corpus based systems have a variety of NLP layers dedicated to analyse given text in order to generate further phrase templates through the use of simplistic grammar rules. (Oh & Rudnicky, 2000, pp. 27-28)

It seems that this initial corpus-based approach has been deemed as efficient as a heuristic of both template and rule based systems (Oh & Rudnicky, 2000, p. 31), and as such may present a valuable resource to those who plan on creating small applications that are highly specialised, thereby requiring experts to weigh in, or that are designed to adapt to user-input.

Although a corpus-based technique for NLG may serve a greater variety of systems and applications, for the purposes of this project a further exploration into the template-based technique will be explored, as it holds the greatest potential merit to the proposed application. As Caropreso et al 2009 have pointed out, “numerous examples [of template-based NLG] exist, most of which are one-off developments” (Caropreso, et al., 2009, p. 2) and seeing as the purpose of this project is to further demonstrate the applicability of NLP and NLG in a computer game environment, a template-based implementation would be most appropriate given the time and development constraints.

When developing a template-based NLG application, it is beneficial to also develop a small program that acts as an assistant to the template authoring experience. *Figure 4b* is a design for such a companion software, it was designed by Caropreso et al 2009 to quickly output possible content for a given template which then served as feedback to users during the template authoring in an attempt to quickly identify potential problems in either communication clarity or context appropriateness. (Caropreso, et al., 2009, pp. 4-5)

Although the previous example implementation of template-based NLG requires a great amount of user interaction in order to narrow down potential issues by setting restrictions on the generated content, it certainly holds merit for the purposes of content generation. However, it should be noted that the system developed by Caropreso et al 2009 was designed for users with little linguistic authoring skills. The hurdle that this system and technique present can be mitigated if the templates are authored by trained narrative authors or, perhaps, if the program also had a layer consisting of a fuzzy inference engine prior to the output of generated content that filters out the most flawed content.

FUZZY NATURAL LOGIC AND CONCLUSION

FUZZY NATURAL LOGIC (FNL)

A combination of fuzzy logic and natural language processing is explored by *Novak 2017* where in an attempt to more directly mimic the logic employed by users and developers alike, in contrast to machines. (Novak, 2017, p. 1) This branch of mathematics is noted by the author as providing a better understanding of linguistic semantics, along with an early stage mapping of the meaning behind verbs, albeit a crude mapping that still requires the input of linguists. (Novak, 2017, p. 5)

This seems to further build upon the works of teams like *Suanmali et al 2009* as they cover some of the same points, where the use of a fuzzy inference system greatly benefits in dealing with some of the ambiguity of natural languages. Although a brief exploration of the field, and not entirely relevant to the project at hand, it seems that FNL may be an interesting avenue in the combination of fuzzy logic and natural language processing.

The exploration of FNL by *Novak 2017* was focused on processing different aspects of linguistic semantics, and decided to do so in an attempt to narrow their scope to the essential components of natural language. (Novak, 2017, p. 2) It should be noted that verbs, arguably a core component of natural language, were deemed too complicated due to the ambiguity and flexibility that they have, as such the field is certainly in its early stages and requires further development. (Novak, 2017, p. 5) However, it can be argued that *Novak 2017*, and the presented application of FNL, further reinforces the feasibility of combining fuzzy logic and natural language processing as it this was also demonstrated by *Suanmali et al 2009*.

BRIEF CONCLUSION

The resources found proved to be valuable sources of relevant information for the project at hand, even if some of the literature was somewhat outside the scope. Although the literature review itself was already narrowed down to a few subjects that are directly relevant to the proposed project, this will most likely result in an even tighter scope of further research as development comes underway.

This tightening is in reference to the techniques that will most likely be employed throughout development; seeing as the NLP techniques relevant to phonological analysis, and the NLG techniques other than template-based generation will not, in all likelihood, be explored in the project.

The lack of phonological analysis was a conscious decision as the proposed product is designed to be a text-based computer game with minimal audio elements. Template-based NLG techniques to generate content was decided as being the most applicable as it allows for greater time to construct cohesive storyline generation without having to rely on an extensive corpus of knowledge. The project will furthermore benefit from the shorter development time that template-based generation requires, without being greatly affected by the limited flexibility that this technique is characterised.

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