# Exemplar-Based Sense Modulation

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**Abstract**

A great deal of psycholinguistic findings reveal that context highlights or obscures certain aspects in the meaning of a word (viz., word sense modulation). Computational models of lexicon, however, are mostly concerned with the ways context selects a meaning for a word (word sense selection). In this paper, we propose a model that combines sense selection with sense modulation. Word senses in this proposal consist of a sense-concept and a sense-view. Furthermore, we outline an exemplar-based approach in which sense-views are developed gradually and incrementally. A prototype implementation of this model for sentential context is also briefly discussed.

## 1. Introduction

The main focus of this paper is the effects of context in modulating the meaning representation of an unambiguous noun as it appears in different contexts. The role of context in many existing computational lexicons ends once one reading, out of a number of contrasting readings, is selected. However, many psycholinguistic findings indicate that context affects the storage and retrieval of concepts. In this paper, we will argue that lexicon models must account for both *sense selection* and *sense modulation* (see Cruse, 1986).

We first motivate our work by emphasizing the inability of existing lexicon models to account for contextual effects at a level finer than the sense level. We then discuss our proposed model, which represents word senses as pairs of **sense-concepts/sense-views**. We will also describe how sense-views evolve from a number of exemplars. The paper concludes with a brief description of an implemented prototype and results of some experiments.

## 2. Motivations

Elsewhere (Rais-Ghasem, 1998), the first author has reviewed existing computational lexicon models and showed that, despite their differences, they all subscribe to the same meaning theory, namely *sense enumeration* (Seidenberg et al., 1982; Simpson and Burgess, 1985). Fundamental to this theory are two assumptions: 1) the possibility of listing or enumerating all possible meanings for each word, and 2) the existence of a selection process in which one of these meanings is selected for a given word.

One of the main disadvantages of such enumerative lexicons is their inability to account for a phenomenon generally known as *semantic flexibility* (see Barclay et al., 1974; Barsalou, 1993; Greenspan, 1986). In short, semantic flexibility concerns changes that context causes in representation of concepts in memory. Many psycholinguistic findings have shown that context seems to highlight or obscure certain properties of a single concept as it appears in different contexts. For example, in an early experiment, Barclay et al. (1974) demonstrated how the interpretations of familiar, unambiguous words vary with context. For instance, they argued that the choice of attributes for *piano* is affected by the verb selection in *The man (lifted) (tuned) (smashed) (sat on) (photographed) the piano*. They then provided evidence that the prior acquisition of a sentence like *The man lifted the piano* (vs. *The man tuned the piano*) influences the effectiveness of cues like "something heavy" (vs. "something with a nice sound") in recall. They concluded that context can affect the encoding of concepts in memory. Similarly, Barsalou (1982) reported that subjects verify contextually relevant properties significantly faster than contextually irrelevant properties

Witney et al. (1985) also report similar results. Their work is particularly interesting since they distinguished between two levels of property activation: 1) the functional level (useful in activities such as sentence comprehension and classification), and 2) the semantic access level (corresponding to the information that is actually accessed upon seeing a word). They used intervals of 0, 300 and 600 ms. and found that all properties of a word were initially activated (accessed), regardless of the context. However, the contextually irrelevant ('low-dominant' in their terminology) properties would die off rapidly, and hence play a negligible role in the overall sentence comprehension.

Greenspan (1986) studied the effect of sentential context on concrete nouns. He examined the presence of central and peripheral properties of a noun in different contexts. For a given a noun, Greenspan presented his subjects with a pair of sentences where in each sentence a different type of properties was emphasized. For example, consider the noun *basket*. Being a container is a central property for *basket* whereas being made of straw is a peripheral one. Each of the following sentences focuses on one of these properties.

The butler placed the letter in the basket.
(Container)
Sally took several days to weave the basket.
(Straw)

Later he examined subjects' recall in various memory tasks and found that the central properties were activated regardless of the context, but peripheral properties were activated only if they were emphasized by the sentence. He further showed that the emphasized central properties were more activated than unemphasized central properties. He concluded that the interpretation of a concrete noun is a function of both the sentential context and the noun's central properties (*Ibid.*).

Anderson et al. (1976) demonstrated that general terms are contextually instantiated to more specific terms. For example, they used fish in contexts like the following sentences and hypothesized that it was likely to be instantiated respectively to *goldfish*, *trout* and *shark*.

The grocer stared at the fish in the bowl.
The grocer stared at the fish in the stream.
The fish attacked the swimmer.

They examined their hypothesis in a number of experiments and found that an expected instantiated term was a better cue for the recall of a sentence then the general term itself, even though the general term had appeared in the sentence and the particular term had not.

To the best of our knowledge, none of the existing computational lexicon models have adequately dealt with semantic flexibility. Having subscribed to the sense enumeration theory, the effects of context in these models are limited to selecting of one sense. Any changes in the characteristics of a selected sense either has to come in the form of a new sense or is ignored.

This requires the ability to foresee any context that a word can appear in and define a separate sense for it. Obviously, this is impractical, if not impossible (see Corriveau, 1995, chapter 2). Thus, any lexicon model must support a combination of sense generation and sense selection.

Of the various computational lexicon models, this issue is specially problematic for symbolic lexicons (e.g., Dyer, 1982; Wilensky, 1978) and lexicons based on semantic networks (Lange & Dyer, 1989; Waltz & Pollack, 1985). This is due to the fact that word senses in these models are coded as discrete entries.

Owing to their adopted continuous representation, connectionist models, however, are potentially capable of dealing with contextual effects at a finer level. In fact McClelland and Kawamoto (1986) reported an unintended yet interesting result. They had presented their model with *The ball broke the vase*. Although throughout the training *ball* was always associated with the microfeature *soft*, in the output it was associated with the microfeature *hard*. They attributed this result to the fact that *breakers* in their experiment were all *hard* and the model had shaded the meaning of ball accordingly.

However, the connectionist approach also has some disadvantages. First of all, connectionist lexicons presuppose a set of universal and fixed microfeatures and demand that every sense be characterized in terms of such microfeatures *in advance*. This constitutes a serious problem for any real world application.

But what is even more important is the difficulty to separate patterns of contextual effects from the representation of a word sense. For instance, consider *breakers* in McClelland and Kawamoto (1986). It is impossible to examine this category of objects by itself. Thus we cannot determine 1) what qualifies an object to be a *breaker* or 2) what else can be a *breaker*?

We believe separating patterns of contextual effects from internal representations of context is important. Firstly, such patterns can be thought of as *ad hoc* categories, categories built by people to achieve goals (Barsalou, 1983). For instance, the *breakers* category can be instrumental in achieving the goal of "breaking a window". Secondly, from a learning point of view, such patterns can be very useful. Rais-Ghasem (1998) has shown how a concept can evolve (i.e., acquires new properties) from such patterns as it appears in various contexts. Also, Rais-Ghasem (*Ibid.*) has employed such patterns to implement a metaphor understanding system that interprets metaphors as class inclusion assertions (see Gluksberg & Keysar, 1990).

## 3. A Lexicon for Sense Modulation

In this section, we propose a lexical model that not only selects senses for input words, but also contextually modulates the selected senses. Examples used in this section are from a prototype implementation of this model for sentential contexts.

### 3.1 Two-Tiered Word Senses

Cruse (1986) specifies two ways in which context affects the semantic contribution of a word: sense selection and sense modulation. Sense selection happens in cases of lexical ambiguity where one sense is chosen among a number of contrastive senses (see Pustejovsky, 1995) associated with a word. In sense modulation, the semantic characteristics of a selected sense are modulated according to its surrounding context. Cruse describes two types of sense modulation: a) highlighting or backgrounding, and b) promotion or demotion of features. In the former, context underlines certain aspects (i.e., properties) of the concept selected for a given word while dimming others, as it happens for *piano* in the following examples:

The musician played the piano.
The musician broke the piano.
The musician lifted the piano.

Context can also promote, or demote, certain aspects of a word's associated concept. For instance, *teacher*, by definition, is gender neutral. However, in a context like the following, the feature gender is promoted for *teacher*.

The teacher stroked his beard.

Similarly, certain aspects can be demoted, as is solidity, a property usually associated with *butter*, in this context:

Mary poured the butter into the jar.

To account for both sense selection and sense modulation, we propose to structure word senses into two tiers: **sense-concept** tier and **sense-view** tier (see Figure 1). While the sense-concept tier specifies the core meaning of a word in a given context, the sense-view tier specifies how this meaning is to be viewed in that context. It is our contention that this simple structure is capable of accounting for various types of sense modulation.

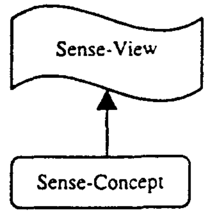

*Figure 1*: Two-tiered word sense.

Here is an example of the word sense generated by the implemented prototype (see section 4) for *piano* in *The musician moved the piano*.

[Sense-Concept(s)] PIANO
[Sense View]
WEIGHT(0.666667)---->:HEAVY,
STATE-OF-MATTER(0.756)---->:SOLID,
IsKindOf-ARTIFACT(0.7047)---->:
COLOR(0.7047)---->:
AGE(0.7047)---->:
OPERATED-BY(0.7047)---->:HUMAN,

As shown, this word sense consists of two parts: a sense-concept and a sense-view. Since concepts to a large extent are conventionalized, sense-concepts are specified only by means of the concepts they represent (concept PIANO in this case). Sense-views, however, are specified as a set of properties (e.g., WEIGHT) and their possible values (e.g., HEAVY). Each property is also accompanied with a number between 0 and 1 indicating the property's weight (or centrality) in a given sense-view. The implemented system relies on the Mikrokosmos ontology (Mahesh and Nirenburg, 1995) to specify properties for sense-concepts and sense-views[1].

Now, compare the above word sense with the word sense generated for *piano* in a different context such as *The musician played the piano*.

[Sense-Concept(s)] PIANO
[Sense View]
IsKindOf-MUSICAL-INSTRUMENT(0.81)---->:
WORK-EQUIPMENT-OF(0.81)---->:MUSICIAN,
IsKindOf-ARTIFACT(0.729)---->:
STATE-OF-MATTER(0.729)---->:SOLID,
COLOR(0.729)---->:
AGE(0.729)---->:
OPERATED-BY(0.729)---->:HUMAN,
IsKindOf-INANIMATE(0.6561)---->:

[1] It must be noted that our model is not dependent on any particular ontology or set of properties. The choice of Mikrokosmos is primarily justified because of its availability and relative comprehensiveness.

Note that the two word senses share the same sense-concept. They differ, however, on their sense-views. Because of the sense-view, the first word sense portrays *piano* as an object of moving (by highlighting properties such as *weight* and *artifact*). Conversely, the second word sense underlines a different aspect of *piano*, namely the fact that it is a musical instrument.

As examples of property demotion/promotion, consider the word senses respectively generated for *musician* in the above two contexts. In the first context, we get:

[Sense-Concept(s)] MUSICIAN
[Sense View]
GENDER(0.885367)---->:MALE,
IsKindOf-HUMAN(0.8187)---->:
IsKindOf-PRIMATE(0.54)---->:

Notice how all properties specific to musician are demoted in this example, since they are irrelevant to the role played by *musician* in this context (i.e., being a *mover*). This is not the case in *The musician played the piano.*

[Sense-Concept(s)] MUSICIAN
[Sense View]
WORK-EQUIPMENT(1)---->:MUSICAl-INSTRUMENT,
AREA-OF-INTEREST(1)---->:FIELD-OF-MUSIC,
IsKindOf-ENTERTAINMENT-ROLE(0.9)---->:
IsKindOf-ARTISTIC-ROLE(0.81)---->:
IsKindOf-SOCIAL-ROLE(0.729)---->:
IsKindOf-HUMAN(0.6561)---->:
GENDER(0.6561)---->:
IsKindOf-SOCIAL-OBJECT(0.6561)---->:

## 3.2 Exemplar-Based Sense-Views

In this section, we outline a lexicon model in which sense-views are developed gradually and incrementally. That is achieved by exploiting *exemplars*[2]. Exemplars are previously processed contexts that exemplify the usage of word senses. In other words, every exemplar consists of a number of word senses, each of the latter formed by a pair of the form (sense-concept/sense-view).

We first define the alike relationship:

*Definition* 1: Sense-concepts $SC_1$ and $SC_2$ are **alike** if they appear in similar contexts, and they share the same thematic role.

For example, according to this relationship, *piano*, *fridge* and *computer* are alike in the following inputs:

They used a crane to move the stove.
John carried the computer.
Four men moved the piano.

In other words, from the view point of "being moved", these representationally different sense-concepts can be classified together.

This parallels the two different roles that Franks (1995) proposed for concepts. He distinguished between the *representational* and *classificatory* functions of concepts. While the former is used to discern instances of one concept from others, the latter specifies how an instance of a concept should be classified. Franks (Ibid.) argues that, depending on context, *fake gun* could be classified along with a *gun*, a *toy*, a *replica*, and a *model*.

Given that all alike sense-concepts share the same sense-view, we can define a sense-view as the intersection of the properties of the sense-concepts that are connected to it. Figure 2 illustrates this situation.

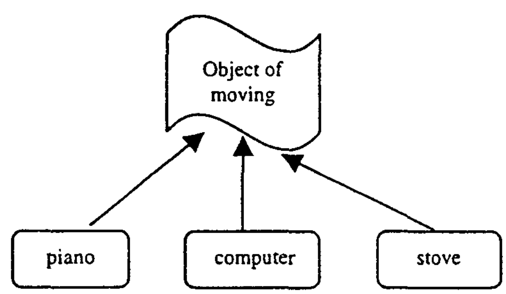


*Figure 2*: A shared sense-view .

A sense-view is initialized to the properties of the first sense-concept to join it. As more sense-concepts join, the sense-view evolves to better reflect what is common between all those sense-concepts. For example, the following is the content of the sense-view object of moving initiated with only one exemplar:

The man moved the stove.

[Sense View]
Thematic Role: Object - No. of Exemplars: 1
WEIGHT(1)---->:heavy,
IsKindOf-COMPLEX-MECHANISM(0.9)---->:
IsKindOf-MECHANISM(0.81)---->:
IsKindOf-DEVICE(0.729)---->:
STATE-OF-MATTER(0.729)---->:SOLID,
MADE-OF(0.729)---->:PLASTIC,METAL,
IsKindOf-ARTIFACT(0.6561)---->:
COLOR(0.6561)---->:
AGE(0.6561)---->:
OPERATED-BY(0.6561)---->:HUMAN,
IsKindOf-COOKING-APPLIANCE(0.9)---->:
IsKindOf-COOKING-EQUIPMENT(0.81)---->:
IsKindOf-EVERYDAY-ARTIFACT(0.729)---->:

This definition gradually becomes more representative of this sense-view as new alike

[2] Similar to *semantic relations* in Cruse (1986).

sense-concepts are included. After adding *computer*, as it appears in:

The student moved the computer.

we get:

[Sense View]
Thematic Role: Object - No. of Exemplars: 2
IsKindOf-DEVICE(0.7695)---->:
STATE-OF-MATTER(0.7695)---->:SOLID,
MADE-OF(0.7695)---->:PLASTIC,METAL,
IsKindOf-ARTIFACT(0.69255)---->:
COLOR(0.69255)---->:
AGE(0.69255)---->:
OPERATED-BY(0.69255)---->:HUMAN,

This trend continues with *piano* in:

The musician moved the piano.

[Sense View]
Thematic Role: Object - No. of Exemplars: 3
WEIGHT(0.666667)---->:heavy,
IsKindOf-DEVICE(0.513)---->:
STATE-OF-MATTER(0.756)---->:SOLID,
MADE-OF(0.513)---->:MATERIAL,
IsKindOf-ARTIFACT(0.7047)---->:
COLOR(0.7047)---->:
AGE(0.7047)---->:
OPERATED-BY(0.7047)---->:HUMAN,

Notice how the picture of "a heavy artifact" is emerging[3]. The modification of a sense-view continues until the sense-view reaches a certain level of stability (for more details, see Rais-Ghasem, 1998).

### 3.3 From Words to Senses

Having described the two-tiered word senses and our adopted exemplar-based approach to develop sense-views, we can now overview the models overall behavior.

Input to the system is a context, presented as a number of input words and along with their syntactic categories and case markers (Delisle et al., 1993). For example, a sentence like *The musician played the piano* would be presented to the model as *musician* (noun, p-subj), *play* (verb, -), and *piano* (noun, p-obj). Case markers p-subj and p-obj respectively indicate "positional subject" and "positional object".

The goal is first, to select proper senses for input words, and second, to contextually modulate those senses. The model attempts to accomplish both tasks by looking for an **adaptable** exemplar. Adaptability between a stored exemplar and an input context is defined as follows:

*Definition 2*: Adaptability between an exemplar context $C_E$ and an input context $C_I$ is a function ($f$) of the compatibility between the sense-views associated with $C_E$ and their thematically corresponding concepts in $C_I$. Compatibility between a sense-view and a concept is defined based on the degree of overlap in their properties.

For instance, assume that the model already maintains the following exemplars:

E1. The musician played the guitar.
E2. Mary played soccer.

Also suppose the following input is presented to the model.

John played the piano.

To determine the adaptability of this input with E1 and E2, we should first find sense-views corresponding to the input words, and then measure their compatibility. Let us assume that we know that the input words *John*, *play* and *piano* respectively correspond to sense-views associated with *musician*, *play* and *guitar* in E1 and sense-views associated with *Mary*, *play* and *soccer* in E2.

Let's begin with E2. It is possible to select a sense for the input word *John* which is compatible with sport-player (the sense-view associated with *Mary*). The same is true for input word play and the sense-view playing-sport. However, finding a sense for *piano* which is compatible with the sense-view *sport* (*soccer's* associated sense-view) is not possible. Therefore, the input context and E2 are not adaptable.

Conversely, E1 and the input context, are adaptable: *John* is compatible with music-player (*musician's* associated sense-view), *play* with playing-music, and *piano* with musical-instrument.

Adaptability, in fact, allows the model to decide if a set of word senses can be selected or generated for the input words. Put roughly, given some input words, the resulting word senses must be reusable together in an adaptable exemplar (see Rais-Ghasem, 1998, for more details).

In *Definition 2*, correspondence between an input word and a sense-view was defined based on the thematic roles. Since thematic roles are unknown for the input words, the implemented system relies on case markers to find corresponding sense-views for an input word.

[3] This process also meets, to some extent, another requirement, namely idiosyncrasy of word senses. For example, the property *heavy* is present in this sense-view only because of its strong presence in the sense-concepts added to this sense-view so far. That may not be the case for another reader and may not hold over time.

Every sense-views maintains a list of case markers (which may evolve as new members join). Here is an example of the sense-view breaking-instrument.

[Sense View]
Thematic Role: Instrument - Marker(s): with-pp, p-subj,
STATE-OF-MATTER(0.73305)---->:SOLID,
MADE-OF(0.82805)---->: MATERIAL,

The markers with-pp and p-subj indicate that *breakers* are usually marked either as subject or with-prepositional phrase in the input. Here are examples:

The thief broke the windshield with a bat.
The rack smashed the window.

Once an adaptable exemplar is found, the model not only knows what senses must be selected for the input words, but also by associating these senses with their corresponding sense-views, the selected senses will be modulated. For example, *John* in the above example will be associated with the sense-view music-player (a case of property promotion). Similarly, the word *play* will be disambiguated to playing-music (as opposed to playing-sport in E2).

# 4. Implemented Prototype

The implemented system is structured in two marker passing networks. The bottom network, the ontology network, serves as the system knowledge base to define concepts in the second network. This definition includes concept properties and relationships between concepts. We used Mikrokosmos ontology (Mahesh & Nirenburg, 1995).

The second network, the lexicon network, consists of four layers of nodes. Figure 3 displays the schematic structure of the lexicon network. Lexemes, (displayed as squares) appear at the bottom. Connected to lexemes are concepts (rounded rectangles). Concepts are connected exemplars (double-lined rectangles). Exemplars consist of a number of sense-concepts (occurrences of concepts in exemplars). Associated with each sense-concept is a sense-view (displayed as banners).

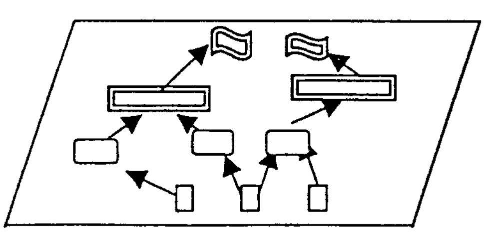

*Figure 3:* The structure of the lexicon network.

The process begins when input words are looked up the in ontology and their corresponding lexemes are found. Concepts connected to these lexemes are then activated which, in turn, leads to activation of all exemplars in which input words appear. Exemplars activated for a word, or more precisely, for the word's associated concepts, represent the model's knowledge, up to that point, of various ways that the input word can interact with other words.

In the implemented system, determining adaptability is carried out simultaneously and concurrently by individual exemplars triggered by input words. Attached to each exemplars (in fact, attached to a group of exemplars with similar context) is an agent. Agents, (implemented as Java™ threads) receive activation and individually start measuring the adaptability of their exemplars with the input. More details can be found in Rais-Ghasem (1998).

# 5. Experiments

This section presents more examples of output generated by the implemented prototype. These examples intend to underline different aspects of the proposed model.

### 5.1 Sense-View Development

This experiment provides another example of sense-view development. The destination sense-view, initially exemplified by only one exemplar:

Mary went to the office.

This is how this sense-view looks like at this time:

[Sense View]
Thematic Role: Destination - Marker(s): to-pp,
IsKindOf-BUILDING(0.9)---->:
IsKindOf-PLACE(0.81)---->:
IsKindOf-PHYSICAL-OBJECT(0.729)---->:
MADE-OF(0.729)---->:MATERIAL,
WEIGHT(0.729)---->:
SIZE(0.729)---->:
IsKindOf-OBJECT(0.6561)---->:
IsKindOf-BUILDING-ARTIFACT(0.81)---->:
IsKindOf-ARTIFACT(0.729)---->:
STATE-OF-MATTER(0.729)---->:SOLID,
COLOR(0.729)---->:
AGE(0.729)---->:
OPERATED-BY(0.729)---->:HUMAN,
IsKindOf-INANIMATE(0.6561)---->:

Notice both IsKindOf-Building and IsKindOf-Place are relatively central to office and therefore to this sense-view. The above set shrinks rapidly after processing the next input:

The student went to the stadium.

SENSE Generated for Input Word Stadium
[Sense-Concept(s)] STADIUM
[Sense View]
Thematic Role: Destination - Marker(s): to-pp,
IsKindOf-BUILDING(0.8145)---->:
IsKindOf-PLACE(0.73305)---->:
IsKindOf-BUILDING-ARTIFACT(0.73305)---->:

This trend continues with the following input, which leads to the following word sense:

John went to the park.

SENSE Generated for Input Word Park
[Sense-Concept(s)] PARK
[Sense View]
Thematic Role: Destination - Marker(s): to-pp,
IsKindOf-BUILDING(0.543)---->:
IsKindOf-PLACE(0.7074)---->:

Here, unlike previous case, IsKindOf-Place is more prominent than IsKindOf-Building. This is because *park* is not a building, but nonetheless, its effect is not enough to completely eliminate IsKindOf-Building from the sense-view. The next input, however, strengthens IsKindOf-Building and weakens IsKindOf-Place, mainly because this property is not immediately present for *auditorium*.

The musician went to the auditorium.

SENSE Generated for Input Word Auditorium
[Sense-Concept(s)] AUDITORIUM
[Sense View]
Thematic Role: Destination - Marker(s): to-pp,
IsKindOf-BUILDING(0.571275)---->:
IsKindOf-PLACE(0.53055)---->:

## 5.2 Property Highlighting/Backgrounding

This experiment provides further evidence on how a single concept in this model can be viewed from different perspectives. Notice how the generated output for *book* changes in each of the following cases.

The book broke the window.

SENSE Generated for Input Word Book
[Sense-Concept(s)] BOOK
[Sense View]
Thematic Role: Instrument - No. of Exemplars: 4 - Marker(s): with-pp,p-subj,
STATE-OF-MATTER(0.73305)---->:SOLID,
MADE-OF(0.82805)---->: MATERIAL,

The student read the book.

This is also a case of lexical disambiguation, or sense selection: *read* could mean announce or study for an academic degree.

SENSE Generated for Input Word Read
[Sense-Concept(s)] READ-IN-MIND
[Sense View]
Thematic Role: Action - No. of Exemplars: 3 - Marker(s): verb,
MODE(1)---->:IN-MIND,
IsKindOf-ACTIVE-COGNITIVE-EVENT(0.9)---->:
IsKindOf-COGNITIVE-EVENT(0.81)---->:
IsKindOf-MENTAL-EVENT(0.729)---->:
IsKindOf-EVENT(0.6561)---->:

SENSE Generated for Input Word Book
[Sense-Concept(s)] BOOK
[Sense View]
Thematic Role: Theme - No. of Exemplars: 3 - Marker(s): p-obj,
CONTAINS(0.666667)---->:INFORMATION,
MADE-OF(0.666667)---->:PAPER,INK,
IsKindOf-PRINTED-MEDIA(0.6)---->:
LOCATION(0.6)---->:ACEDEMIC-BUILDING,
IsKindOf-VISUAL-MEDIA-ARTIFACT(0.54)---->:
IsKindOf-DOCUMENT(0.57)---->:
PRODUCED-BY(0.57)---->:HUMAN,
IsKindOf-LANGUAGE-RELATED-OBJECT(0.513)---->:
REPRESENTS(0.756)---->:OBJECT,EVENT,LANGUAGE,

And finally *book* as an object of moving.

The musician moved the book.

SENSE Generated for Input Word Book
[Sense-Concept(s)] BOOK
[Sense View]
Thematic Role: Object - No. of Exemplars: 4 - Marker(s): p-obj,
STATE-OF-MATTER(0.731025)---->:SOLID,
MADE-OF(0.63475)---->:PLASTIC,METAL,
IsKindOf-ARTIFACT(0.69255)---->:
COLOR(0.69255)---->:
AGE(0.69255)---->:
OPERATED-BY(0.69255)---->:HUMAN,

## 5.3 Property Promotion/Demotion

This experiment provides an example of how one concept appearing in a context can be associated with properties not necessarily present in its original representation. Here is the input context:

Mary reads physics.

Because of its appearance in this context, *Mary* (in fact, its corresponding concept, Female-Human) will be depicted as *student*. In other words, through the assigned sense-view, properties specific to student (e.g., being a social/academic role) will be associated with *Mary* in this context. The experiment also provides another example of the system's lexical disambiguation ability (*read* is ambiguous). Here is the output word sense for *Mary*.

SENSE Generated for Input Word Mary
[Sense-Concept(s)] HUMAN-FEMALE
[Sense View]
Thematic Role: Agent - No. of Exemplars: 1 -
Marker(s): p-subj,
IsKindOf-ACEDEMIC-ROLE(0.9)---->:
IsKindOf-SOCIAL-ROLE(0.81)---->:
IsKindOf-HUMAN(0.729)---->:
GENDER(0.729)---->:
IsKindOf-PRIMATE(0.6561)---->:
IsKindOf-SOCIAL-OBJECT(0.729)---->:
IsKindOf-OBJECT(0.6561)---->:

### 5.4 Multiple Word Senses

There are cases in which context does not favor any of the alternative readings of a word, and therefore the ambiguity must be maintained in the output. This experiment demonstrates the system's ability to handle such cases. In this example, both readings of *bank* are compatible, to some degree, with the destination sense-view.

John went to the bank.

Here is the output word sense for *bank*, with two sense-concepts, both linked to the same sense-view.

SENSE Generated for Input Word Bank
[Sense-Concept(s)] RIVER-BANK, BANK-BRANCH
[Sense View]
Thematic Role: Destination - Marker(s): to-pp,
IsKindOf-BUILDING(0.51585)---->:
IsKindOf-PLACE(0.5967)---->:

### 5.5 Instantiation of General Terms

This last experiment is inspired by the experiment conducted by Anderson et al. (1976). These researchers found that *shark* was a better cue than *fish* for subjects in remembering a sentence like the following:

The fish attacked the man.

They concluded that *fish* was instantiated to, and encoded accordingly as, *shark* in the subjects' memory.

Here is the word sense generated for *fish* in the above context. Notice how in the output, *fish* is associated with properties specific to shark (*aggressiveness* and *black color*).

SENSE Generated for Input Word Fish
[Sense-Concept(s)] FISH
[Sense View]
Thematic Role: Agent - Marker(s): p-subj,
COLOR(1)---->:BLACK,
AGGRESSIVE(1)---->:
IsKindOf-FISH(0.9)---->:
IsKindOf-VERTEBRATE(0.81)---->:
IsKindOf-ANIMAL(0.729)---->:
GENDER(0.729)---->:
IsKindOf-ANIMATE(0.6561)---->:

### 5.6 Unknown Words

Finally, here is an example of how sense-views can be used to establish some properties about unknown words. Here is the input:

Mary went to the palladium.

The word *palladium* is not defined in the lexicon. Nevertheless, the system associates it with the proper sense-view. Through this sense-view, some initial properties for *palladium* can be inferred.

SENSE Generated for Input Word Palladium
[Sense-Concept(s)] *** unknown ***
[Sense View]
Thematic Role: Destination - Marker(s): to-pp,
IsKindOf-BUILDING(0.51585)---->:
IsKindOf-PLACE(0.5967)---->:

## 6. Conclusion

In this paper, we discussed a lexicon model in which the role of context is not limited to sense selection. Selected senses are further modulated according to their surrounding context. We also described the implementation of a prototype for sentential contexts.

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