FORMAT for the BODY of the RESEARCH PROPOSAL
University Research Coordination Office
(attach to the first 2 pages above)

I. Research Title Automatically Extracting Conceptual Relations from Children's Stories

II. Proposal Abstract (50-100 words)

People use storytelling as a natural and familiar means of conveying information and experience to each other. During this interchange, people understand each other because we rely on a large body of shared common sense knowledge. But computers do not share this knowledge, causing a barrier in human-computer interaction and in applications requiring computers to generate coherent text. To support this task, computers must be provided with a usable knowledge about the basic relationships between concepts that we find everyday in our world.

Picture Books is a story generation system that generates stories for children age 4-6. To achieve this, it uses a semantic ontology containing conceptual knowledge about objects, activities and their relationships in a child's daily life. But the task of building this knowledge base is tedious and time consuming, thus limiting the variants of stories and themes that Picture Books is able to generate.

This research involves the development of a software tool that will automatically extract concepts and their relations from children's stories, and store these in a knowledge base that Picture Books and other NLP applications can utilize to do their tasks.

III. Introduction

Natural language processing systems use a set of knowledge base in order to do their tasks. But simple lexicons and large unstructured corpora may be insufficient to support the requirements of these systems. Storytelling, for instance, is a natural task for humans. Armed with a library of words, their meanings and their relationships, we combine words and events to tell stories about ourselves, our community, and our experiences. In order for computers to achieve the same level of expressiveness and be able to understand the world that we talk about, they must be provided with the same shared collection of common sense knowledge about the basic relationships between things and events that nearly every person knows[1].

Recent creative text generation systems (Hong and Ong, 2009) have utilized a semantic network representation of concepts on common sense knowledge to identify relationships of words in human puns in order to generate computer puns. Another system, Picture Books (Solis et al, 2009), generates stories with moral characters for children age 4-6, by using a semantic ontology, patterned after ConceptNet (Liu and Singh, 2004a), containing conceptual knowledge about objects, activities, and their relationships in a child's daily life. The process of building and populating the Picture Books ontology required a lot of manual effort on the part of the proponents. Currently, the ontology contains 240 concepts and 369 relations, which were populated based on the themes that have been identified as relevant for the target age group.

Early Information Extraction (IE) systems have addressed the extraction of information from relatively small collections of well-structured documents such as newswire or scientific publications (Muslea, 1999). More recently, IE systems are focused on extracting facts from structured and unstructured documents for a particular domain, such as legal documents (Cheng et al, 2008).

Although IE systems are capable of recognizing entities within documents (e.g. 'Renoir' is a 'Person', '25 Feb 1841' is a 'Date'), the relation between the entities (e.g., 'Renoir' was born on '25 Feb 1841') was not extracted, thus generating incomplete information that may be needed by certain applications (Banko and Etzioni, 2008). A variant of IE, Relation Extraction (RE), is the task of recognizing the assertion of a particular relationship between two or more entities in text.

[1] Commonsense Computing Initiative at MIT Lab, http://csc.media.mit.edu/

The task of relation extraction is difficult, but relations such as hypernymy (is-a) and meronymy (part-whole) are often expressed using a small number of lexico-syntactic patterns (Hearst, 1992). Using a sample set of 500 sentences selected at random from an IE training corpus, Banko and Etzioni (2008) showed that many binary relationships are also consistently expressed using a compact set of relation-independent lexico-syntactic patterns.

The Artequakt project (Alani et al, 2003) also showed that it is possible to automatically acquire such relations from documents to populate an ontology. Working in the domain of artists, the Artequakt project identifies relations between entities of interest within sentences, following ontology relation declarations and lexical information. These relations are then used to populate an ontology with knowledge triples for use in the generation of biographies of artists.

Although both IE and RE have achieved significant progress in extracting facts and concepts in the domains of newspapers (Muslea, 1999), biographies (Alani et al, 2003), and legal documents (Cheng et al, 2008), limited work has been done on children's stories. Furthermore, since stories contain sequences of actions that characters perform or experience at various points in the story world, knowledge about how these events are ordered and the constraints under which they can occur must also be extracted.

To convey the ideas of a story, Nakasone and Ishizuka (2006) developed a storytelling ontology model by identifying relations between sentences in the story using the Rhetorical Structure Theory (RST) of Mann and Thompson (1987). As Knott and Dale (1994) pointed out, explicit and implicit relations hold between the sentences of a text, so that the content of one sentence might provide justification, elaboration or explanation for the content of another. These relations bind a text together to contribute to the overall comprehension of a story by the readers; for instance, whether understanding one text span (scene of a story) increases the reader's readiness to understand another scene, or whether understanding both spans allows the reader to recognize a particular semantic relation as holding between them. Certain discourse relations or cue phrases, such as *but*, *so*, *although*, *more precisely* or *for example*, are used to signal explicit relations between text spans.

The knowledge base derived from extracting entities, concepts, and events can then be used for various applications. One such application is in story generation. Picture Books can use the knowledge base to generate more variants as well as longer stories. Currently, Picture Books generates stories containing 24 – 30 sentences, which not only vary according to the age of the reader, but is also dependent on the available relations between two concepts. Story generating applications can in turn be used for both educational and entertainment purposes.

In education, Riedl and Young (2004) applied narrative generation techniques to generate historical fictions for teaching history, which they defined as "the chronological record of significant events". Lester and his colleagues (2007) explored integrating narratives into learning environments that teach microbiology to provide an "adaptive, effective pedagogy that is both motivating and meaningful".

In entertainment, story generation is applied to develop interactive fiction systems. Montfort (2009) defines interactive fiction as "a venerable thread of creative computing and a literary art". His Curveship project uses NLP techniques to create narratives in the virtual world, where the user directs the possible flow of the story. For his knowledge base, Montfort utilized a tree representation that describes the possible sequences of events and the relationship of events to one another, as well as models of objects in the virtual world. A similar system in the game area, Façade (Mateas and Stern, 2003) is a 3D interactive drama that makes use of artificial intelligence techniques to allow players to interact with the characters in the story by playing as one of the characters and typing textual commands that affect the flow and the outcome of the game (story). Young (2008) is also exploring the development of computational models to generate narratives for 3D virtual game environments, which are being considered as alternative approach to promote learning.

Story understanding system can also benefit from using the knowledge base. Story understanding requires an enormous amount of commonsense knowledge, thus the question and answering system of Mueller (2007) has a limited scope focusing on modeling the spatial and temporal aspects of narratives involving one or two characters dining in a restaurant. He employed a combined technique using IE to extract key information about dining episodes, and commonsense reasoning to build models of the dining episodes. The model is limited to only a single spatial layout consisting of the street, the dining room, and the kitchen, and further work can be done to extract information about the spatial layout from the text, and use this to construct models of room-scale space.

Research Objectives

This research aims to automatically identify and extract the relations between everyday concepts and objects from children's stories and store them in a semantic network to provide ontological knowledge for Picture Books.

The specific objectives of the research are as follows:

- Collect a corpus of children's stories
- Analyze the English sentence structures in the corpus to derive a set of extraction patterns
- Develop a representation for modeling relations of every object common in children's stories
- Design the algorithm for acquiring common sense knowledge automatically from the corpus
- Implement the algorithm
- Validate the resulting conceptual relations extraction tool through integration with Picture Books

Assumptions, Scope and Limitations

At least 30 children's stories will be collected to form the input corpus for the extraction tool to be developed. Analysis of the English sentence structures in these stories will be performed to identify the types of relations that are present. This information will be used to derive a set of patterns or templates for extracting conceptual relations. A software extraction tool will be developed to use the extraction patterns to automatically locate instances of a known relation in the corpus.

One relation may be expressed in various ways in text. Consider the hypernymy (isa) relation, wherein the following sentences are possible ways of expressing it:

The dog is a canine.
The dog is a kind of canine.
The dog, a canine, is …
The dog is a type of canine.

Although lexico-syntactic extraction patterns mapped directly to relations, certain English sentence constructs require further analysis and decomposition in order to derive their corresponding relations. These include sentence structures containing conjunctions and embedded clauses, as shown in the examples below:

Cake is made of flour, sugar, <u>and</u> butter.
The boy is singing <u>and</u> the girl is dancing.
Anna, <u>who is the queen</u>, went to the market, <u>while</u> the king went to the mall.

Text structures in stories may contain rhetorical relations to reflect the semantic relations that may exist between concepts and events in a story. Using the Rhetorical Structure Theory (RST) of Mann and Thompson (1987), these relations may be identified and extracted to provide additional conceptual knowledge.

Extracted knowledge must be stored in a representation model that can be used by NLP systems, in this case, the Picture Books story generator. Part of the research will involve reviewing the design of the Picture Books ontology, which is patterned after the design of ConceptNet, to validate the presence of the appropriate relations against those identified from the collected corpus.

Since stories are sequences of events, their analysis may necessitate the creation of new relations to represent sequences of events, temporal relations between events, as well as the constraints under which certain events may take place. For example, during testing, evaluators noticed that one of the generated stories of Picture Books occurred at an inappropriate time; specifically, the first segment of the story that introduces the day, the place, and the main character, contained the following text:

The evening was warm. Ellen the elephant was at the school. She went with Mommy Edna to the school.

Since Picture Books' knowledge base currently does not provide relations about when certain events can occur, the main character went to school in the evening.

At least 20 new semantic relations, resulting from those identified using RST, from analyzing the sample corpus, and from reviewing other works such as Mueller for modeling time and event occurrences (discussed further in Section IV Theoretical Framework), may be created in this research.

Alani (2003) noted that it is inevitable for duplicate and contradictory information to be extracted from the input corpus. But he further noted that handling such information is challenging for automatic extraction and ontology population approaches. Thus, this will not be considered in the current proposal.

Mueller (1999) also noted that "story understanding goes beyond generating parse trees, disambiguating words, or filling templates, and includes the ability to answer arbitrary questions, generate paraphrases and summaries, fill arbitrary templates, make inferences, reason about the story, follow reasoning in the story, relate the story to general knowledge, and hypothesize alternative versions of the story." Thus, aside from having a huge collection of commonsense knowledge, a computer system must also be able to "make inferences about states and events not explicitly described in the text" (Mueller, 2003), by performing commonsense reasoning using knowledge about the world. This requires a multi-representational model of this knowledge for the various realms of space, time, needs and feelings to be built, and will be beyond the scope of the current proposal.

Manual validation through a linguist may be utilized to check that correct conceptual relations were extracted and stored in the ontology. Automated validation will also be performed by having Picture Books utilize the new knowledge in generating stories.

The following are indicators of a successful validation of the contents of the resulting ontology:

- There is an increase in the number of story variants that are generated by Picture Books.
- The length of the generated stories for older kids (i.e., 5- to 6-year old users), measured in terms of the number of sentences, also increases as additional information becomes available. Note that Picture Books currently placed a limit to the maximum number of sentences that will be generated for younger readers.
- The coherency of the generated stories will also increase, as new knowledge improves the narrative information presented to the reader.

Significance of the Study

Researches in the field of natural language processing (NLP) seek to find ways to make human-computer interaction more fluent. But human-computer communication is hampered by the lack of a shared collection of common sense knowledge that people rely on when they communicate in order to understand each other. In order to make computers achieve the same level of expressiveness as humans, we must give them "a common language with richness that more closely approaches that of the human language" (Niles and Pease, 2001).

Although dedicated IE systems have been developed to extract information from various domains, this research is a first step towards extracting relations from children's stories. Storytelling is a natural and familiar means of conveying information and experience to listeners (Nakasone and Ishizuka, 2006), thus justifying the selection of this domain for the proposed research.

Various applications can utilize the knowledge extracted by the system from existing stories. The major beneficiary will be story generation systems that require a large body of commonsense knowledge to do their tasks. Story generation systems are currently gaining grounds in both education and entertainment. Various research projects have shown that using stories can stimulate learning, and virtual environments where the user's choices have an effect on the flow of the story also promotes creativity and encourage user participation.

IV. Theoretical Framework/Methodology

An ontology is an artifact with a set of representational primitives to model knowledge for a particular domain (Gruber, 2008). The representational primitives are classes or objects, attributes of the objects and relationship of each object. The design of the semantic ontology of Picture Books is patterned after ConceptNet (Liu and Singh, 2004a), a large-scale common sense knowledge base.

The nodes used by ConceptNet are of three general classes representing noun phrases, attributes, and activity phrases. A semantic relation connects two concepts while a semantic category classifies them. The semantic relations are binary relation types defined by Open Mind Commonsense project (Liu and Singh, 2004b). Table 1 lists some of these relations defined in Picture Books following the form `<relationship>(<concept1>, <concept2>)`.

Picture Books generates a story for a given input picture that contain a background selected by the user from the background library, as well as the character and object stickers placed onto the background. The ontology is used to derive relations between concepts, which refer to objects in the picture as well as the theme associated by the system through the background. An excerpt of a generated story and the corresponding conceptual knowledge used is shown in Table 2.

Semantic Category	Semantic Relationships
Things	***IsA***(headache, pain) ***PropertyOf***(apple, healthy) ***PartOf***(window, pane) ***MadeOf***(toy car, clay)
Events	***FirstSubeventOf***(tell bedtime story, sleep) ***EventForGoalEvent***(go to grocery store, buy food) ***EventForGoalState***(clean up, be neat) ***EventRequiresObject***(play, toy)
Actions	***EffectOf***(become dirty, itchy) ***EffectOfIsState***(make friends, friendship) ***CapableOf***(toy car, play)
Spatial	***OftenNear***(sailboat, water)) ***LocationOf***(teacher, school)
Functions	***UsedFor***(thermometer, check temperature)

Table 1. ConceptNet semantic relationships (Liu and Singh, 2004b) with sample concepts of Picture Books

Line	Story Text	Conceptual Knowledge
1	Rizzy the rabbit was in the living room.	
2	She played near a lamp.	
		CapableOf (lamp, break) ***ConceptuallyRelatedTo*** (break, break object)
3	Rizzy broke the lamp.	
		EffectOf (break object, be scared)
4	She was scared.	
	:	
5	Rizzy told Mommy Francine that Daniel the dog broke the lamp.	
	:	
		LastSubeventOf (break object, get punished)
6	He got punished.	
		LastSubeventOf (get punished, grounded) ***isA*** (grounded, punishment)
7	Mommy Francine told Daniel that he was grounded.	
		LastSubeventOf (grounded, cry)
8	He cried.	

Table 2. Excerpt from a story generated by Picture Books with corresponding conceptual knowledge

In line 1, the main character (*Rizzy the Rabbit*) and the setting (*living room*) were determined from the character sticker placed onto the selected background by the user. In line 2, the object (*lamp*) may or may not be in the picture, but included in the generated story based on the theme that is associated to the background. In this example, the theme is *being honest* through admitting your mistake (that is, the main character must not lie about breaking the lamp).

Access to the ontology is needed to derive events that can happen next in the story, as shown in line 3, and the effects of the resulting event, shown in line 4. Line 5 is the starting point of the rising action, where the main character misbehaves (*told a lie*) and the subsequent events and effects of the misbehavior. All the knowledge needed by Picture Books to do its task were manually encoded by the proponents into the system, based on the identified background and themes, which are appropriate to the target age group. The knowledge in ConceptNet cannot be used directly as these are not suitable for the users of Picture Books.

The ConceptNet semantic network was populated with concepts and relations through a distributed solution of acquiring common sense knowledge from the public using a web-based data entry mechanism of the Open Mind Common Sense (OMCS) project (Hvasi, Speer, and Alonso, 2007). OMCS employs both semi-structured and free-form data entry approaches. The semi-structured approach utilizes extraction patterns commonly used by IE systems. Each extraction pattern or template has slots that users can fill-up, and is mapped directly to a relation.

Given the template "*< X > is a kind of < Y >*", the possible values for ***<X>*** and ***<Y>*** that users can provide and the corresponding hypernymy (***IsA***) relations that are acquired are shown in Table 3.

<X>	<Y>	Relations
Apple	Fruit	IsA (apple, fruit)
Ball	Toy	IsA (ball, toy)
Rose	Flower	IsA (rose, flower)

Table 3. Sample values to derive the hypernymy (***IsA***) relations

Table 4 shows other extraction patterns and the corresponding relations of ConceptNet.

Extraction Pattern or Template	Relations
CAKE is a kind of FOOD.	IsA (cake, food)
CAKE is made of FLOUR.	MadeOf (cake, flour)
FLOUR is WHITE.	PropertyOf (flour, white)
The effect of DRINKING MILK is GOOD HEALTH.	EffectOf (drinking milk, good health)

Table 4. Sample extraction patterns and corresponding ConceptNet relations

From the examples above, an instance of an extraction pattern generates one relation. But sentences may contain conjunctive phrases, which in turn may result to multiple relations being learned, as shown in Table 5 for the pattern "*< X > is made of < Y >*". This will be explored further in this research.

Extraction Pattern or Template	Relations
CAKE is made of FLOUR, SUGAR, and MILK.	MadeOf (cake, flour) MadeOf (cake, sugar) MadeOf (cake, milk)

Table 5. Generating multiple relations from a single extraction pattern

Part-of-speech tags may also be utilized to identify phrases and its constituents. For example, in Table 6, the noun phrase used to fill the ***<X>*** variable in the ***is-a*** template has three components, namely an article ("*the*"), an adjective ("*sweet*"), and a noun ("*cake*"). Extracting this knowledge can lead to the relation *PropertyOf (cake, sweet)*. This will be explored further in this research.

Input Sentence following a Template	Relations
< X > is a < Y > The sweet cake is a dessert. NP(art adj n)	Explicit extraction pattern: IsA (dessert, cake)
	Implicit from POS tag: PropertyOf (cake, sweet)

Table 6. Utilizing POS tags for implicit relations

The input stories may contain complex sentence structures, such as conjunctions and embedded clauses. Text simplification algorithms, employed in SimText (Damay et al, 2007) may be utilized to convert these sentence structures into simpler ones. Consider the sentence "*Anna, who is the queen, went to the market; meanwhile, the king went to the mall.*" By identifying and transforming this to three simpler sentences: "*Anna is the queen. She went to the market. Meanwhile, the king went to the mall.*", the following relations can be extracted. This will be explored further in this research.

IsPerson (Anna)
HasRole (person, queen)
HasRole (person, king)
CapableOf (person, go)
TargetOf (go, market)
TargetOf (go, mall)

This example shows some of the possible new relations that may be included in the output of the proposed system, namely:

- HasRole to designate that characters may play certain roles
- RoleResponsibleFor to model a specified role is responsible for a given task, e.g., the king rules a country
- TargetOf to model target objects of certain actions

One of the identified limitations in the current knowledge base of Picture Books is the lack of relations to denote event occurrences. Consider again the text:

The evening was warm. Ellen the elephant was at the school. She went with Mommy Edna to the school.

If appropriate relations are available, e.g., Happens to designate that an activity, such as going to school, can only happen at a certain time of day, such as morning, then the resulting text can be:

The morning was sunny. Ellen the elephant was at the school. She went with Mommy Edna to the school.

Certain granularities may be provided to the relations representing various aspects of time, namely season (planting can only occur during spring, snow can only fall during winter), month (Christmas in December, Valentine's in February), or even weeks, days, hours, and minutes.

Mueller (2003) made use of event calculus consisting of the following predicates to model event occurrences:

- Happens(e, t) represents that an event *e* happens at time *t*.
- HoldsAt(f, t) represents that a fluent *f* holds at time *t*.
- Initiates(e, f, t) represents that if event *e* occurs at *t* then fluent *f* starts holding after *t*.
- Terminates(e, f, t) represents that if event *e* occurs at *t* then fluent *f* stops holding after t.

Nakasone and Ishizuka (2006) developed a concept representation model to convey ideas of a story, by identifying organizations of text structure using the Rhetorical Structure Theory of Mann and Thompson (1987). RST relations can then be mapped to existing ConceptNet relations, as shown in Table 7. This will be explored in this research.

RST Relation	ConceptNet Relation
Cause (one event is the cause of another event)	EffectOf (event1, event2)
Background (one event serves as background information for the other)	EventForGoalEvent (clean up, be neat)
Example	InstanceOf

Table 7. Mapping of RST relations to ConceptNet relations

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