Understanding Children Arabic Educational Texts through Keywords Extraction, Ontology and Multimedia Elements

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ABSTRACT: *Teaching children with intellectual disabilities is a challenging task. Instructors should repeat the same lessons several times. They should use also different methodologies to introduce the concepts and motivate the children and keep them engaged. These methodologies include: reading texts, showing images, touching items, taking children to sites, and even using the taste and smell senses. The objective of this work is to develop a system that can assist the children to improve their understanding of simple educational texts related to specific domain through multimedia technology. We use formal concepts analysis to extract keywords from the texts and generate the graphical user interfaces. We link the keywords with the multimedia elements (i.e., images and clips) which are retrieved from Google search engine by using Google APIs features. We build also databases of keywords with their synonyms in both Arabic and English and the corresponding multimedia elements. Every student can have his/her own database that contains the objects that he/she learnt. The instructors can select the appropriate multimedia elements according to the levels of theirs students. They can input the education text, set the domain, and build specific multimedia contents that can fit with every student in the classroom.*

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1. Introduction

Children with mild and moderate intellectual challenges face a lot of problems in understanding simple educational texts and stories. Special education instructors use different techniques in order to explain the concepts to the children and keep them motivated and engaged [5, 6]. These techniques include reading the texts several times in different ways, designing glossy images about the objects, actions and characters of the texts and show them to the children, generating sounds whenever necessary (i.e., birds, cats, dogs, camels, wolf) and objects (i.e., cars, motorcycles, bus, airplanes), and even using the taste and smell senses [13]. Finding or developing the previous items is problematic, time consuming and hard. The instructors ask their assistants to look for these items from different resources like books, magazines, newspapers and the Internet. They sometimes draw the characters and record the corresponding sounds in their schools. The children in the same classroom have also different understanding levels of understanding even though they have been classified as having the same intellectual challenges. These children need always different and additional images, clips and sounds in order to understand the texts. Developing an intelligent system that can get as input the educational text and generates the corresponding multimedia contents will be of great importance for both teachers and children as well as for their parents. In fact, children can understand better the concepts, teachers can improve the learning process as they have a collection of multimedia elements related to the educational texts; also the parent can use the system at home to help their children to review the lessons. We propose in this work the first prototype of an assistive educational system based on interactivity and multimedia elements. We use formal concept analysis techniques FCA [7, 9] to extract the keywords from the text and we link them automatically with corresponding multimedia elements (i.e., images, sounds, and short clips). We use mainly the features available in Google APIs [8] which allow us to query Google search engine and retrieve the multimedia elements in the domain of discourse. We have built also a database of keywords with their synonyms and the associated multimedia elements. This database is growing gradually with every studied text and the new keywords are added to it. The list of synonyms words is formed using WorldNet.Thesaurus [18]. In addition, every child will have his/her own multimedia database which will be expanded with the acquired knowledge using our technique proposed in [12]. Special education instructors can select the appropriate multimedia elements according to the understanding levels of theirs students. They can input the educational text to the system and build specific multimedia content. The proposed system will improve the understanding and communication skills of the children with intellectual challenges and help them understand educational texts related to the animal and food domains in an enjoyable and funny manner. The main keywords like the story characters (e.g., dog, wolf, lion, rabbit, zebra) and actions (e.g., bark, attack, eat, howl) are set by using a specific ontology that is built for the animal and foo domain. This ontology allows to recognize the objects, characters and relationships between these entities.

We mention that in our previous work, we have developed some algorithms to map texts into sentences, then sentences to list of words using formal concepts analysis FCA and Galois connection [1,2]. These algorithms are used in the proposed system. We used an open source stemmer to extract the roots of the keywords which will be matched against the ontology and linked with the multimedia elements. We have set so far two domains which are foods and animals. As a matter of fact, animal-related texts are among the best attractive domain for children. Our approach is different from the techniques proposed by Chelin et al. [4] who used natural language processing to extract the keywords from texts. We can apply our techniques on texts of different languages like English, French, German and Arabic, in the selected domain and we can get the same effective results.

2. Formal Concepts Analysis Background

In this section we discuss briefly the formal concepts analysis FCA that are used to extract keywords from texts and generate a graphical user interface that links the sentences of the text with the extracted keywords.

The notion of formal concept has been introduced by different scientific communities in the world starting from 1945, by Riguet [7] under the name of maximal rectangle, and in graph theory as a maximal bipartite graph. In addition it has been exploited in 1986 in the thesis of N. Le Than [7] in database concepts to introduce a new kind of dependencies called, iso-dependencies. Among the mathematical theories found recently with important applications in computer science, lattice theory has a specific place for data organization, information engineering, data mining and reasoning. It may be considered as the mathematical tool that unifies data and knowledge, as well as information retrieval and reasoning.

In FCA terms, a space of information can be modeled as a formal context which is a triple (O, P, I) where O is the set of objects in that information space, P is the set of properties owned by some objects and $I \subseteq O \times P$; i.e. I is the binary relation that is a subset of the product of the set of objects and the set of properties in that information space.

Example 1. Let O be the following set O = {Leech, Bream, Frog, Dog, Spike-weed, Reed, Bean, Maize}, and let P be the following set P = {a, b, c, d, e, f, g, h, i} where O is a set of some animals, and P is a set of the following properties: a = needs water, b = lives in water, c = lives on land, d = needs chlorophyll to produce food, e = is two seed leaves, f = one seed leaf, g = can move around, h = has limbs, i = suckles its offspring. The binary context R is given in the table 1 below.

A concept of a binary context is a binary relation that can be defined in terms of its objects (intents) and their shared attributes (extents) to be the collection of the maximum number of objects (set O) sharing the collection of the maximum number of attributes (set P). More formally, let f be a function from the powerset of the set of objects O (i.e., 2O) to the powerset of the set of properties P (i.e., 2P), such that: $f(A) = \{m \mid \forall g \in A \rightarrow (g, m)\ R\}$; f (A) is the set of all properties shared by all objects of A (subset of O) with respect to the context R. Let g be a function from 2^P to 2^O, such that:

$$g(B) = \{g \mid \forall m \in B \rightarrow (g, m)\ \ R\};$$

g(B) is the set of objects sharing all the properties B (subset of P) with respect to the binary context R. We define the closure function as follows:

$$closure(A) = g(f(A)) = A', \text{ and } closure(B) = f(g(B)) = B'$$

The formal concept is formally the pair (A, B), such that f(A) = B, and g(B) = A. We call A the extent and B the intent of the concept (A, B). If (A1, B1) and (A2, B2) are two concepts, (A1, B1) is called a sub-concept of (A2, B2), provided that $A1 \subseteq A2$, and $B2 \subseteq B1$.

In this case, (A2, B2) is a super-concept (A1, B1) and it is written as follows: (A1, B1) < (A2, B2). The relation "<" is called the hierarchical order relation of the concepts. The set of all concepts of (G, M, I) ordered in this way is called the concept lattice of the context (G, M, I).

A formal context can be represented as a hieratical concept lattice structure. Such structures have the tendency to grow exponentially in terms of the number of concepts they include. This problem is known to be NP complete [7] for which there have been a number of approximations to find the minimum number of concepts that can represent the maximum knowledge in a lattice with the minimal redundancy to save processing power and resource consumption. For that purpose, we have adopted in the proposed system a greedy approach for finding the minimal number of concepts entirely covering a binary relation based on a space optimization criterion. This techniques is described in details in [11].

3. System Components

The proposed system consists of different components. The core application components handle the processing of educational texts and converts the extracted keywords in the domains of food and animals into multimedia elements. These components are given in the following sub-sections.

3.1 The Text Processing Component

One of the most important components is the initial text processing component which handles the stemming process and conversion of the text into a binary relation mapping keywords in the text to the sentences they appear in. This means that the sentences will constitute the set of objects while the words will represent the set of attributes. Two words will be considered identical if they share the same lexical root or stem. The *Stemmer Service* and the *Part of Speech Service* shown in Figure 2 represents the text processing component.

3.2 The FCA Extraction Component

This component handles the conceptual analysis part of the system. It extracts the minimal number of optimal concepts entirely covering the binary relation corresponding to the original input text. The optimality of a concept is calculated using the space optimization factor called concept weigh and defined later in section 3.3. The output of this component is considered as a short intermediary representation of the significant ideas and concepts in the text. The *Content Service* in Figure 2 represents the FCA extraction component.

3.3 The Learning Component

The learning component comprises the usage of the animal and food ontology to aid the named entity extraction and the part of speech tagging processes. The input to this component is the sentences contained in the extracted concepts generated by the FCA extraction component. The *Ontology Service* given in Figure 2 represents the learning component.

3.4 The Multimedia Mapping Component

The multimedia mapping component is responsible for mapping the short representation of the text generated by the FCA extraction component into reusable multimedia elements to aid the learning process for children with intellectual challenges.

4. System Architecture

The proposed system architecture is based mainly on service oriented architecture SOA [14]. Using external component such as Google services, our target is to utilize SOA to consume available multimedia search solution that will translate concepts and actions expressed in representative text segments into multimedia elements. Below screenshot shows some attempts of using Google APIs to find the multimedia elements corresponding to the sentence "*dog eats meat*".

Figure 1. An example of a multimedia search service from Google

		a	b	c	d	e	f	g	h	i
1	Leech	1	1	0	0	0	0	1	0	0
2	Bream	1	1	0	0	0	0	1	1	0
3	Frog	1	1	1	0	0	0	1	1	0
4	Dog	1	0	1	0	0	0	1	1	1
5	Spike-Weed	1	1	0	1	0	1	0	0	0
6	Reed	1	1	1	1	0	1	0	0	0
7	Bean	1	0	1	1	1	0	0	0	0
8	Maize	1	0	1	1	0	1	0	0	0

Table 1. Binary context R between objects and attributes

The figure-2 below shows the components of the proposed system distributed into modular layers. This gives some flexibility when any modification is required. Modifying one layer doesn't affect the others layers.

5. Ontology

The ontology is one of the most significant parts of the learning component of the system. An ontology represents usually the concept which is separately identified by users domains, and used in a self-contained way to communicate information [10,16]. Ontology describes basic concepts in a domain and defines relations among them. Basic building blocks of ontology design include: classes or concepts, properties of each concept describing various features and attributes of the concept, restrictions

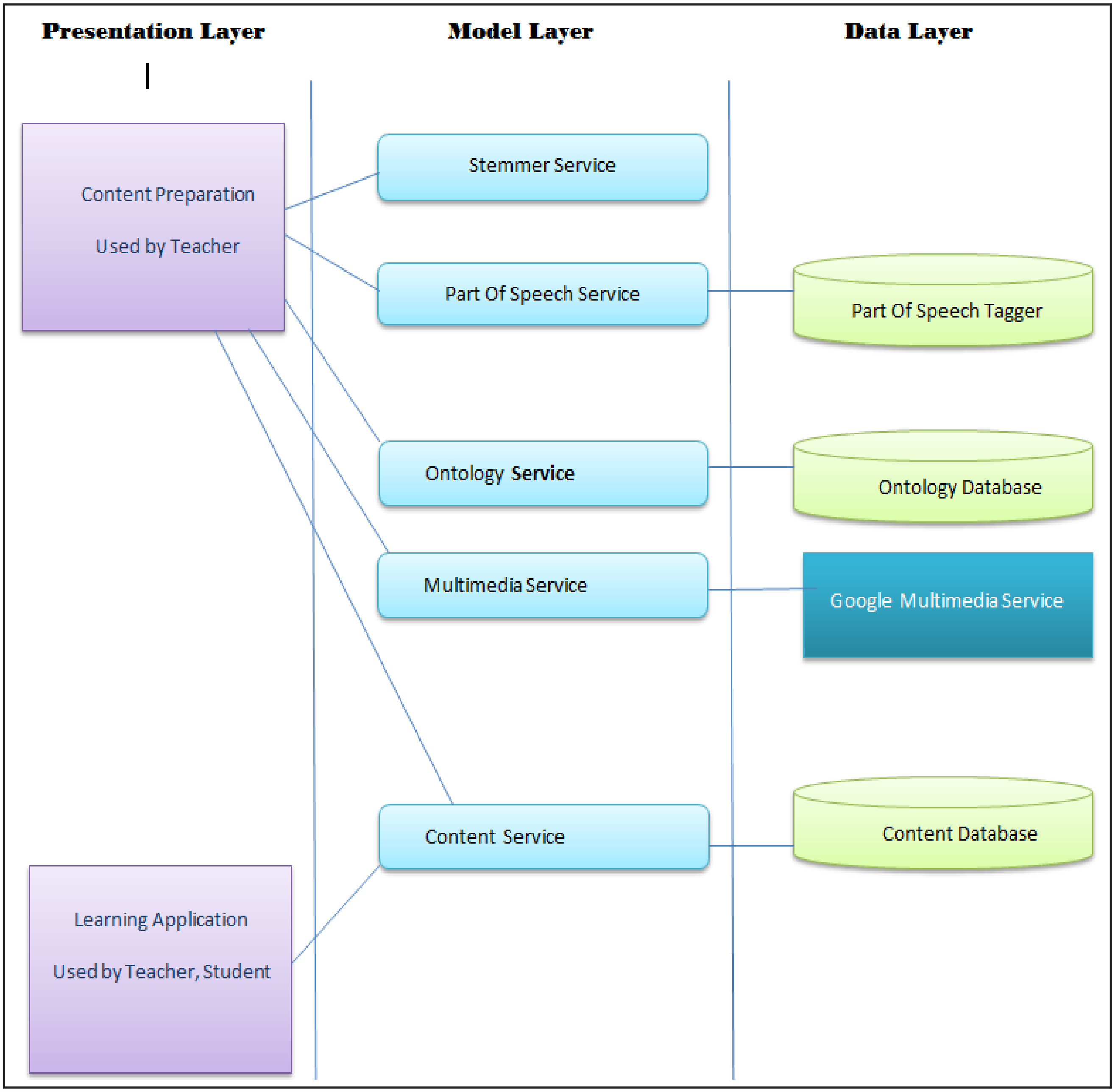


Figure 2. The components of the assistive educational system

on slots (facets). In the context of the current application, children mostly read Arabic texts. After having built a corpus of texts, an ontology of the animal and food domains is generated manually. The ontology is structured around different basic named entities. These entities include animals, food, habitats, actions, time period, objects, food, places, countries, etc. Using some basic entities, we defined different events related to texts about animals and foods. Some of the defined events include: eating, playing, hunting, etc. An event is structured by means of basic entities, for example, the event "*eating*" is composed of named entities: animal, food, and location, meaning that some animal is eating some food somewhere. A simple animal and food ontology can group the names of animals with eventually their images and the relations between other objects belonging to the domain like "*meat*" and "*herbs*". We can discover or infer from the ontology that the monkey and the camel eat herbs while the lion and the dog eat meat. Also we can infer that the lion can attack the rabbit which is the prey.

Ontology development needs expert in the domains. For the time being, we build a simple ontology that groups some animals and foods, their images and their actions. This ontology will be enriched in the next step of this project by adding other terms like animals habitats (i.e., a camel lives in desert, a lion lives in the forest, a fish lives in the sea or river, etc.), behavior (i.e., attack, climb, crawl), locomotion (i.e., how an animal gets around -by swimming, flying or climbing). The extension will be based on the texts used by the instructors in the Shafallah center for children with special needs. These instructors can also contribute to the enrichment of the ontology. The following figure 3 shows a simple instance of the animal and food ontology with their names, actions and images.

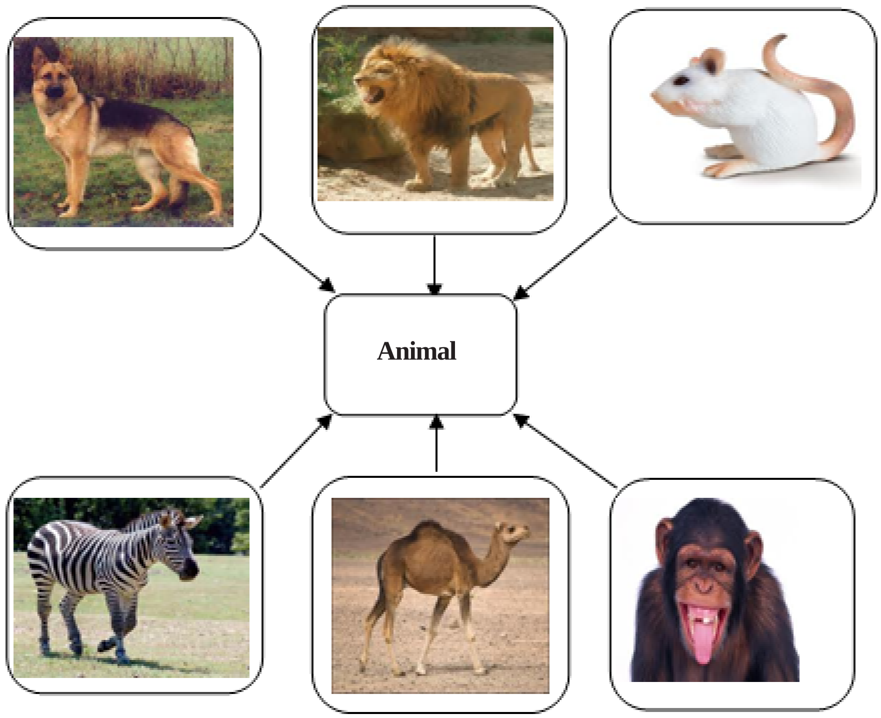


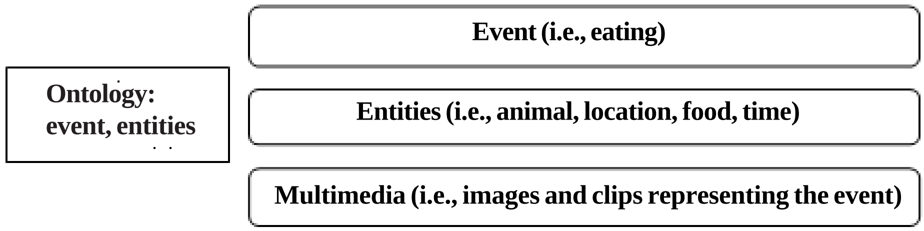
Figure 3. Entities representing animals belonging to the animals and foods ontology with the relations between them

We mention that an important ontology for animals is proposed by the US (NRSP-9 animal traits ontology project) and Europe (EADGENE and SABRE). It includes trait information for animals and species and group scientific and industrial terminologies. In addition, it describes the relations and characteristics of objects. The teams have also developed a thesaurus called "*Wikisaurus*" accessible only to the SABRE members. Another animal ontology is the "*Wildlife ontology*" [17] which consists of a set of simple vocabulary for describing biological species and related taxa. The vocabulary defines terms for describing the names and ranking of taxa, as well as providing support for describing their habitats, conservation status, and behavioral characteristics. Others ontology related to the animal domains is the animal behavior ontology [3]. The application will thus assist the teacher to create the needed domain based on the following structure.

Example 2. "A dog is eating some meat in the morning in the forest". Event: eating. Entities: animal (dog), Food: meat, Period: morning, Location: Forest. Multimedia: Generation of animated scene representing a dog eating meat in the forest in the morning.

6 . Concepts Extraction Based on Ontology

Starting from the named entities, a set of single or composed terms are given a priority during automatic concept recognition, as for example the dog is recognized as an instance of entity animal, and "10-02-2012" is considered as an instance of the entity date. During the conceptual analysis phase, starting from a text, a binary context R relating each sentence to any word belonging



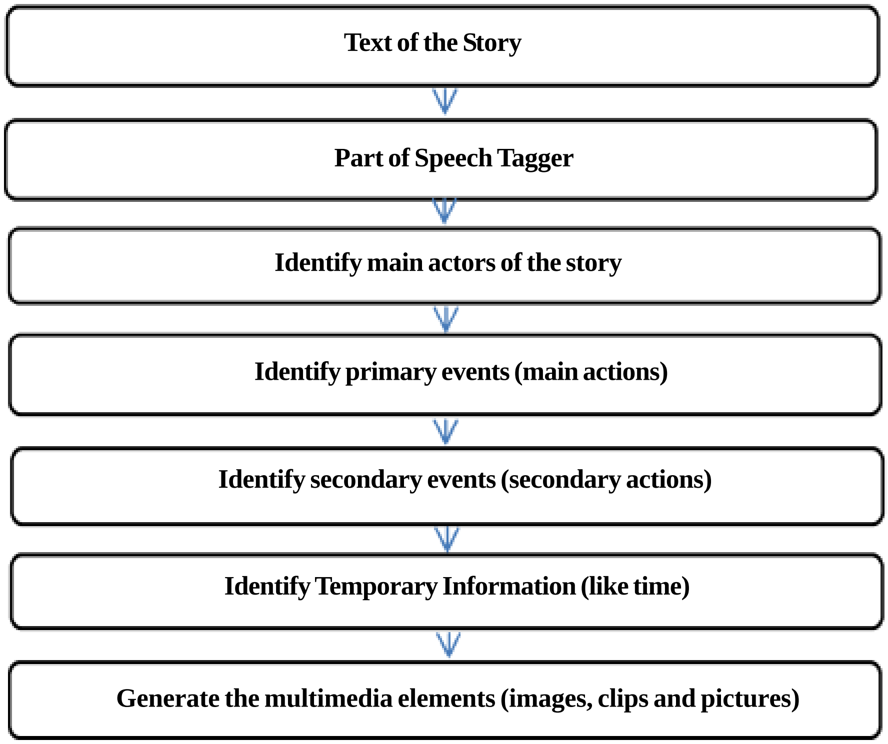
to it is built. Starting the binary context R, a conceptual clustering is realized as described in the following algorithm: for each pair (sentence(s), word(w)), we associate a weight as the product of the number of sentences sharing word w by the number of words belonging to sentence s. By starting with the pair of the highest weight, a pre-restriction of relation R by the antecedents of w and post-restriction by the set of the image of s, should either correspond to a concept (i.e. complete bipartite graph), or a union of several concepts. In the first case, the concept is selected and an adequate label (or name) of the concept is generated. This name is used to communicate the main concept of the text that later we map to an image. In the second case, the algorithm is repeated in the sub-graph. The algorithm ends as soon as coverage of relation R by obtained concepts is obtained. During the process during labeling a priority is given to words belonging to instances of the named entities.

Example 3. "*Four cats are waiting for their lunch every day in the morning, the mother and its three children. The cats jumped on the table in the garden all together, looking to me with insistence asking for their regular lunch. As soon I open the door of the kitchen, they come to me trying to cross the door. Finally, I give them some fish or meat in their room in the garden. Other cats in the neighborhood come at the regular time and try to get something to eat. The number of cats is increasing year per year in the garden*".

We can algorithmically express the steps for generating the multimedia mapping algorithm as follows.

```
Algorithm: map_story
Input: Story textual manuscript Doc.
Output: Story Multimedia manuscript Mult.
begin.
     BR = text_proc(Doc); //convert Doc to Binary Relation
     BR:[Sentences]x[words]
     Cov[C1, C2, .. , Cn] =  extract_coverage(BR);
     //Cov: Ordered concepts list by weight
     for each concept Ci in Cov
       for each Si in  Ci
          temp = pos(Si)
     //Apply part of speech tagging to sentences,extract
     //events and generate named entities
     Mult += get_multimedia(temp);
     Return Mult;
end
```

Using the developed algorithm, the system gives the following words in decreasing order: cats(4), garden(3), lunch(2), door(2), come(2), waiting(1), regular(1). Starting from the selected words, the system shows only sentences related to the corresponding concepts. The multimedia tool mapped the sentences to an image representation, to help for communicating the ideas of the story to children with mental difficulties, by adding sounds and text to help a better knowledge of the vocabulary. For each of the identified concepts, the corresponding set of sentences are passed to the part of speech tagger and the named entity extractor. The resulting sentences are then passed to the Google service for retrieving the corresponding multimedia elements.



7. A Case Study

The steps of the proposed system can be summarized as follows:

We make the keywords extraction based on the ontology related to the domain of animals. Similar ontologies can be built for other domains. The instructors can validate the retrieved multimedia elements that can suit the children intellectual levels. All the multimedia elements will be stored in the multimedia database, where every child will have his/her own sub-database.

Example 4. Assuming that the story text is the following: *"King lion lay in his cane felling very ill. The wolf hated the fox, he told the lion terrible stories about the fox. The fox arrived in time to hear the end of them. He saw how angry the lion was. I have been searching for a cure for your illness. If you wrap the skin of a wolf around you, you will feel better. The lion killed the wolf and wrapped his skin round him."*.

Using FCA, the stemmer and the ontology we can extract the binary representation of the text breaking into sentences and corresponding keywords that are then mapped to the relevant multimedia elements. The process of generating part of speech by using Part of Speech Tagger representing in XML format.

[NNP]King[/NNP] [NN]lion[/NN] [VBD]lay[/VBD] [IN]in[/IN] [PRP$]his[/PRP$] [NN]cane[/NN] [VBG]felling[/VBG] [RB]very[/RB] [JJ]ill[/JJ] [.].[/.] [DT]The[/DT] [NN]wolf[/NN] [VBD]hated[/VBD] [DT]the[/DT] [NN]fox[/NN] [,],[/,] [PRP]he[/PRP] [VBD]told[/VBD] [DT]the[/DT] [NN]lion[/NN] [JJ]terrible[/JJ] [NNS]stories[/NNS] [IN]about[/IN] [DT]the[/DT] [NN]fox[/NN] [.].[/.] [DT]The[/DT] [NN]fox[/NN] [VBD]arrived[/VBD] [IN]in[/IN] [NN]time[/NN] [TO]to[/TO] [VB]hear[/VB] [DT]the[/DT] [NN]end[/NN] [IN]of[/IN] [PRP]them[/PRP] [.].[/.] [PRP]He[/PRP] [VBD]saw[/VBD] [WRB]how[/WRB] [JJ]angry[/JJ] [DT]the[/DT] [NN]lion[/NN] [VBD]was[/VBD] [.].[/.] [PRP]I[/PRP] [VBP]have[/VBP] [VBN]been[/VBN] [VBG]searching[/VBG] [IN]for[/IN] [DT]a[/DT] [NN]cure[/NN] [IN]for[/IN] [PRP$]your[/PRP$] [NN]illness[/NN] [.].[/.] [IN]If[/IN] [PRP]you[/PRP] [VBP]wrap[/VBP] [DT]the[/DT] [NN]skin[/NN] [IN]of[/IN] [DT]a[/DT] [NN]wolf[/NN] [IN]around[/IN] [PRP]you[/PRP] [,],[/,] [PRP]you[/PRP] [MD]will[/MD] [VB]feel[/VB] [RBR]better[/RBR] [.].[/.] [DT]The[/DT] [NN]lion[/NN] [VBD]killed[/VBD] [DT]the[/DT] [NN]wolf[/NN] [CC]and[/CC] [VBD]wrapped[/VBD] [PRP$]his[/PRP$] [NN]skin[/NN] [NN]round[/NN] [PRP]him[/PRP] [.].[/.]

Figure 4. An example of actions identified and their corresponding actors

Figure 4. shows how the system identifies the main actors of the text from the part of speech generation results. It shows also how the system identifies the actions that are applied to main actors of the text.

Figure 5. The retrieved multimedia elements corresponding to the original text of the story. These elements consists of thousands of images and clips where the instructors can validate them and build his/her multimedia story

Example 5. "*A lion attacked a Zebra and killed him then he ate him and got tired so he laid down on a tree branch*".

For this text the system will extract first the named entities like the "*lion*" and "*zebra*" as they belong to the animal ontology. Then it will detect the action "*attack*" and the related objects understanding that the lion is acting on the zebra. In fact, the ontology helps to infer that based on lion's behavior. In the third step, the system understands the killing and feeling actions "*killed*", "*gets tired*", "*laid down*", and the object "*tree branch*" and display then the corresponding multimedia elements. These relations are also existing in the ontology. Some of these relations are: A lion can attack animals like Zebra and a rabbit. A rich ontology can improve the inference process and the outcome of the system. The instructors will have to validate the retrieved elements that should be presented to the children. These elements can includes images of the story characters (i.e., lion and Zebra) and objects (i.e., tree branch) and also their actions like "*attack*", "*fill tired*", and "*kill*". The following figure 4 can be a possible output of the original text which should be formed mainly by the instructor.

8. Conclusions

We have proposed a new multimedia system designed to teach children with intellectual challenges in a very innovative and interactive way. We have used formal concepts analysis with an open source stemmer to extract the keywords from the educational texts and we linked them with multimedia elements. These elements were retrieved from the Internet using Google APIs features. An Ontology of the animal and food domains was built and used to map the most meaningful words from the texts to the corresponding images. A filtering algorithm can be added to the system to avoid getting offensive or harmful contents. The system is promising and should be used for children with intellectual challenges in the Shafallah Center in Doha, Qatar for analytical evaluation. We will Improve the system interface so that the instructors can display the images retrieved from the Internet in different ways. A list of synonymous words should also be formed and used to recognize the entities tin the text. For instance the animal lions which means Assad in Arabic has the following synonyms: "*Shebel*", "*Layss*", "*Drgha'm*", "*Sabeh*", "*Malek Al Ghabah*", "*Malek Al Al Hayawana't* ". Once one of these words occurs in the text the multimedia elements associated with the animal lion will be displayed.

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