

## Extracting Occupational Therapy Concepts to Develop Domain Ontology

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**Abstract—** Recently, unstructured data on the World Wide Web has generated significant interest in the extraction of text, emails, web pages, reports and research papers in their raw form. Far more interestingly, extracting information from a specific domain using distributed corpora from the World Wide Web is a vital step towards creating corpus annotation. This paper describes a method of annotation, based on Occupational Therapy (OT) concepts, to build domain ontology using Natural Language Programming (NLP) technology. We used Java Annotation Patterns Engine (JAPE) grammar to support regular expression matching and thus annotate OT concepts using a GATE developer tool. This speeds up the time-consuming development of the ontology, which is important for experts in the domain facing time constraints and high workloads. The rules provide significant results: the pattern matching of OT concepts based on the lookup list produced 403 correct concepts and the accuracy was generally higher. Using NLP technique is a good approach to reducing the domain expert's work, and the results can be evaluated.

**Keywords—** *Ontology; Information extracting; Regular expression; Natural Language Programming.*

### I. INTRODUCTION

The semantic web offers semantic annotations that describe web resources explicitly. These annotations are based on ontologies that represent domain knowledge through defining concepts and the semantic relations between those concepts. It requires standards of machine-processable representations of ontology. The standards for this purpose, such as Resource Description Framework (RDF) [7], Web Ontology Language (OWL) [5], have been defined by the World Wide Web Consortium (W3C) [13]. Consequently, ontology is a foundation that is central to the growth of the semantic web that provides a common knowledge for correspondence and communication among heterogeneous systems. Furthermore, it is useful for different applications to share information among heterogeneous data resources [1].

Recently, Information Extracting (IE) has received significant interest due to the number of web pages emerging on the internet containing unstructured data. Because of the amount of information available on the internet, it is

necessary to have a tool for extracting it. Many specialists in the field of IE have worked to find suitable tools, such as Wrappers, that classify interesting data and map them onto appropriate formats such as XML or relational database. Furthermore, some HTML-aware tools are based on inheriting the structural features of documents so as to extract the data. Natural Language Programming (NLP) is a technique used by many tools to extract the data in natural language documents. Tools like GATE use techniques such as a part-of-speech tagging, filtering, or lexical semantic tagging to link relevant information, and identify relationships among phrases and sentence elements within text [4]. Each of these tools has advantages and disadvantages. A comparative analysis of the existing tools for data extraction is needed to assess their capabilities. This is done in the next section.

In this paper, first, we provide a brief background to IE tools to justify why we feel the NLP technique should be used to speed up the building of an Ontology of Occupational Therapy (OTO). To extract concepts in the field, we used CREOLE plug-ins from GATE in the IE system. We also show how the JAPE grammar has been implemented by detailing the rules we use to annotate IS concepts. The paper is structured as follows: In Section 2, we discuss the background of ontology and IE. In Section 3, we discuss the methods used to develop domain ontology of OT and extracting OT concepts, to show how they were constructed. In Section 4, is the implementation that shows how the domain knowledge is acquired for creating the corpus, Gazetteer, and how the JAPE rule [16] is implemented. Our discussion and evaluation is in Section 5. Finally, in Section 6, we draw conclusions and make suggestions for future work.

### II. BACKGROUND

#### A. Domain ontology

It is a shared belief that ontology receives a lot of recognition from various research fields. Although there are some well-known domain ontologies, such as CYC, the Standardized Nomenclature for Medicine (SNOMED, a

clinical terminology) [8], Toronto Virtual Enterprise (TOVE) [10], and the GENE ontology (GO) [5], study of the ontology area is still immature and improvements are needed [9].

Occupational Therapy (OT) is a treatment using certain activities to improve physical, mental and social performance. The main objective of the treatment is development of the individual's personal autonomy, both social and professional. The therapist is one of a multi-disciplinary team to work with a stroke patient, for example.

OT has a big problem with a language; it needs a formal language to identify certain concepts in the field, to make communication easier between therapists and between people and machines. "Occupational therapists seem to have difficulty finding appropriate words with which to think about and express the nature and purpose of their practice" [10].

Although many attempts have been made to find a full agreement on specific concepts in the area, the problem still remains to identify the key concepts and their relationships. However, ontology in a specific domain provides concepts and the relationships between these concepts. Furthermore, it offers sharing vocabularies in a consistent mode. More crucially, in natural language, therapists use different meanings for one concept, for instance "occupation, function". If you looked at the Oxford dictionary you might find more than one definition.

Ontology specifies a formal definition to avoid vagueness and ambiguity, to decide the exact meaning. If you looked in the Oxford Dictionary for the meaning of occupation you will find many definitions; at the same time, many therapists, social and health staff, use different words and phrases to define occupation, such as daily activities, everyday life, persons of any age, individual and sociocultural value, leisure and so on; so ontology provides a single definition to make communication more effective.

#### *B. Information Extracting IE*

A number of studies have shown that applications of IE can be used to annotate documents that are written in natural language.

Certainly, the growing number of IE tools that can be used to annotate concepts, such as SHOE, Annota, Annozilla, MnM, Ontomat, COHSE, Melita, and GATE, makes it easy to process machine-readable text [14]. A comparison of these tools shows that they provide distinct methods of IE [1, 13], as illustrated in Table 1.

Table 1 shows that there are many tools such as SHOE, Annota Annozilla and KIM ontotext providing automatic annotation of extracted text from mark-up languages such as RDF OWL HTML, XHTML, written by different languages, e.g., Java and C. In comparing GATE developer with these tools, GATE provides semi-automatic and automatic annotations in easy to use ways, similar to the MnM ontology editor. GATE can extract text from different formats such as XML, HTML, XHTML, emails and PDF files, while MnM annotates HTML formats only.

Basically, the annotation of IS concepts is based on the GATE developer, which is an architecture tool for text engineering. It is a free open source tool developed by a team at the University of Sheffield, starting in the early 1990s [4]. The first version was released in 1995, the second one was in 2002, while the most recent in 2010.

GATE can run on any platform and supports JAVA 5.0. It has also been developed and tested on Linux, Windows and Mac OS X. It has a user interface to enable user editing and visualization and quick application development. Furthermore, it provides support for manual annotation, semi-automatic and semantic annotation as well as ontology management. Moreover, GATE uses CREOLE plug-ins as objects for language engineering. All of these are packaged as Java Archives and XML configuration data [4].

GATE is a tool used to take unseen texts and convert them into a fixed format such as XML or HTML. This data can then be displayed for users or stored in a database for analysis. Before talking about GATE in more detail, we should clarify the difference between Information Retrieval (IR) and IE [3]. IE helps the user to extract information from a huge amount of text for the purpose of fact analysis. IR is just pulling out documents containing relevant information according to a key word search. IE can identify queries in a structural way and provides knowledge at a deeper level, while IR uses a normal queries engine which makes it hard to gain accurate answers, and provides knowledge at the standard level.

Consider an enquiry such as 'which UK airports are currently closed due to severe weather conditions?' Or, where an event took place and who it involved, such as where was Gordon Brown's last visit as prime minister [2, 14].

IR would just provide a webpage containing the relevant information and the user would then need to search that webpage using various terms or concepts to analyse the information. IE, on the other hand, provides specific information about the enquiry; even if the information is not

TABLE I. INFORMATION EXTRACTING TOOLS

Tools	Type	Degree of automation	Based on	Ease of use	Language written in	Advantages & Disadvantages
SHOE	Knowledge annotation	Automatic		+	Java	Allows users to mark up pages in SHOE, guided by ontologies or URL
Annota	Annotation schema W3C	Automatic	RDF mark-up XML,XHTML,CSS &Xpointer	+	C Available for Windows, Unix and MAC	Does not support IE; like an ontology server; makes annotation publicly available
Annozilla	Email annotation	Automatic	Mozilla	++		-
MnM	Ontology editor	Semi-automatic & automatic	HTML	+		Similar to Melita
Ontomat		Automatic	OWL	++		Used to create and maintain ontologies; uses OtoBroker as server
COHSE	Integration of text-processing components	Automatic	DAML+OIL	+	RDF	Uses ontology server to mark up pages in DAML+OIL and reuse as RDF
Melita	Annotation interface	Semi-automatic	Extensible mark-up language, Java, HTML	++		To retrieve structure and semi-structured annotations
KIM ontotext	Semantic annotation platform	Automatic	RDF	++		Semantic annotation, indexing, and retrieval of unstructured and semi-structured content.
GATE	Annotation tool	Semi-automatic & automatic	XML, HTML, XHTML, emails	+++	JAVA version 5	Comprises an architecture and framework. Based on NLP group

accurate, but you can only back up the correct information [11]. IE has been used for applications such as text mining, semantic annotation, question answering, opinion mining, decision support, rich information retrieval and exploration. GATE has a comprehensive set of plug-ins, including Alignment, ANNIE, Annotation\_Merging, Copy\_Annots\_Between\_Docs, Gazetteer\_LKB, Gazetteer\_Ontology\_Based, Information\_Retrieval, Keyphrase\_Extraction\_Algorithm, Language\_Identification, Ontology\_Tools, and WordNet.

GATE is based on ANNIE, which is a new IE system with core processing resources [4]. ANNIE relies on a finite state algorithm and JAPE grammar, and combines Tokenisor, which divide the text into simple tokens such as words, numbers, punctuation, Sentence Splitter, which splits the text into sentences, and abbreviations of gazetteer list helps distinguish between sentences. The POS tagger, Name entity tagger, and JAPE transducer uses JAPE grammar to produce entities, Orthomatcher (co-references),

to match rules to identify the relations between names already found by the POS tagger. The Gazetteer is a list presenting a set of names, terms, etc. to identify entities based on the list. Among these modules, we used Tokenisor, Sentence splitter, Gazetteer, and JAPE transducer [7].

GATE includes automatic and semi-automatic semantic annotation as well as manual annotation, which enables the user to create their own annotations. As a result, the GATE developer can be used to extract terms and concepts from a specific text effectively and efficiently. For this work, we annotate OT concepts from literature to be formalized into OTO ontology code.

### III. METHODS EMPLOYED

Our method of creating OTO ontology is as follows:

#### A. Specifications

A.1 Identify goals, strategy and boundary of the ontology. It is necessary to identify the domain interest and scope from the initial stage of the development process. It helps to construct the conceptualization of the domain. In

this stage there are many questions that need to be answered as recommended by Uschold and Grüninger, which are similar to the competency questions. These questions put together the resources that cover the ontology’s objects, purposes, scope and granularity

- What are the general characteristics of OTO ontology? To answer this question we should describe the content of the ontology including: taxonomic organization, the kind of concepts it will cover at top-level division, internal structure of the concept.
- What is the scope of the domain - will it cover the general domain or be specific?
- What is the purpose of OTO ontology?
- Identify targeted users, applications and functional requirements.
- Choose knowledge acquisition method and tool
- Choose tool to create the ontology

*A.A.2 Knowledge acquisition*

Before creating the ontology, we had to collect the OT concepts for the domain model. Our approach consisted of annotating these concepts based on the JAPE grammar, using the GATE software. The annotation process began by:

- Creating a corpus of documents and a Gazetteer of OT, with JAPE rules used to extract OT concepts. GATE provides facilities for loading corpora for annotation from a URL or uploading from a file. The process generally started as follows:

We compiled OT knowledge from different resources and various publications.

- We analysed the data to ensure it covered the whole field.
- We transferred the information resources into an XML file to form the corpus.
- We uploaded the corpus into the GATE software so as to start running ANNIE.
- We annotated the concepts based on JAPE grammar, which is run within ANNIE.
- Testing and evaluation. As illustrated in Figure 1.

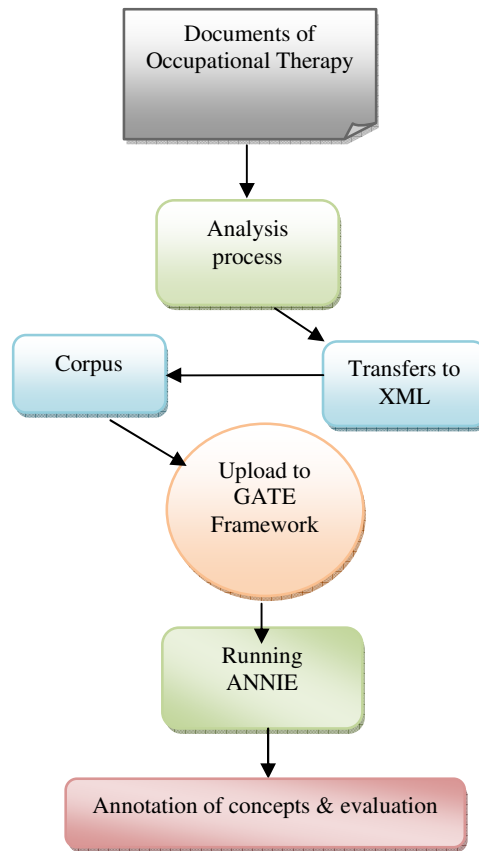


Figure 1. Annotation workflow

*B. Conceptualisation*

This stage starts by:

- Creating a glossary of terms to identify which terms need to be included in the ontology; the glossary includes the term names, synonyms, acronyms, and descriptions of each term.
- Building concept classification.
- Building the data dictionary to identify the concepts with their meaning, instance, class attributes, and their relations.
- In the data dictionary, the instances attributes should be described in more detail, and class attributes also need to be described.

*C. Formalisation:*

The ontology needs to be formalized by transferring the conceptual model into a formal model and to be

coded using the chosen knowledge representation languages and tools, such as OWL and Protégé [6].

D. *Evaluation*: ontology needs to be assessed, so its contents need to be tested and verified to satisfy the real world that needs to be modeled.

E. *Documentation*: facilitates the reusability of the ontology design. Figure 2 depicts the method of OT developing the ontology.

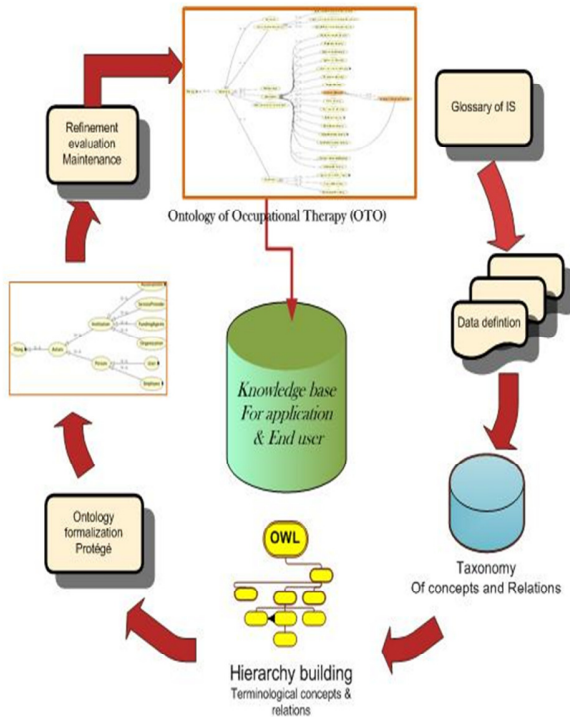


Figure 2. Method of constructing OTO ontology

#### IV. IMPLEMENTATION

1. Identifies the main goal of the OTO ontology which is seeking for providing information for therapists that helps them to:

- Provide valuable information about the patients.
- Provide information on daily service and activities.
- Enables effective occupational performance.

2. Knowledge acquisition started by:

- Creating the corpus. It has 300 files in the XML format, containing text relevant to the IS field.
- *Creating* the IS Gazetteer: This is a list of OT terms that have to be identified as Major Type, Minor Type, etc. For example:

*Productivity: major type= concept*  
*Personal Care: minor type= term*  
*Activities: major type= concept*

- *Next we use JAPE rules:*

Using JAPE rules allows us to extract concepts and identify tokens that contain the concepts in the correct order, and then look up the concepts in the Gazetteer. JAPE rules create a phase based on Java for creating specific grammar. Each JAPE rule consists of Left-Hand-Side (LHS) that contains the pattern that must be matched and Right-Hand-Side (RHS) that details the annotations that are to be created [4].

The JAPE grammar was used to support regular expression matching, as this is how annotation is achieved in GATE. Annotation can also be carried out using other CREOLE plug-ins such as Gazetteer, for which it is necessary to create a list of concepts to be annotated. By clicking on the ANNIE Gazetteer, all the lists appear, including the OT list, as shown in Figure 3. The sub-list presents the main concepts, such as Action, Task, Interactions, social role and Developmental.

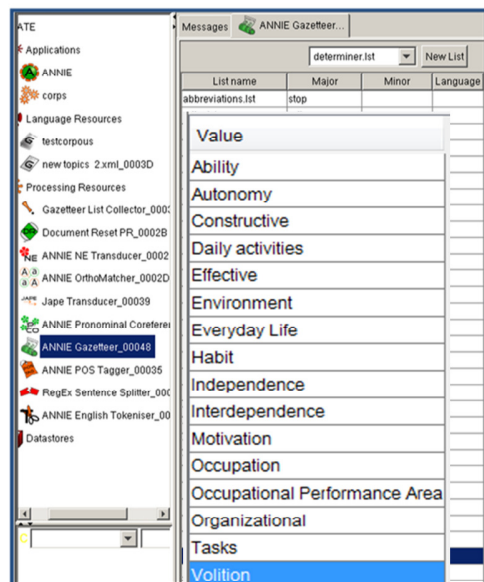


Figure 3. Screenshot of OT Gazetteer

- The next step was uploading the corpus to the application framework using the JAPE grammar and Gazetteer to match and annotate concepts from the corpus.
- *NLP technique used to extract OT concepts:*

We present an automatic extraction method based on ANNIE using a JAPE grammar that extracts concepts from XML files and HTML text. Our JAPE rule extracts concepts as follows: the first entity detected is Information service {Type=Token, start=867, end=837, id=4210, majorType=concept} labelled as *Occupational Therapy.concept*.

Phase: one

Input: Lookup Token  
Options: control = applet

```

Rule: concept1
Priority: 20
(
  ({Token.string == "occupational"})
  {Token.string == "therapy"}
  ({Lookup.major Type == "concept"})
): occupational
-->
: occupational.concept = {Rule=concept1}
    
```

In these rules, we specify a string of text {Token.string == } that must be matched, specifying the attributes of the annotation by using operators such as “==”, and then annotating the entities according to the correct labels. Furthermore, using a control field such as all, applet, brill gives the right results. The next example shows how regular expressions could be annotated as showing concepts related to (Therapy) metacharacter(dot, \*, [ ], | ), {Token.string == "therap (ies)" }.

### 3. Creating Glossary:

All terms were gathered along with the relevant information to be described in the glossary. We collect the terms from the point of view of occupational practice and therapists, see Table 2.

TABLE 2. GLOSSARY OF TERMS

Occupation	Role	Ability
Occupational mapping	Routine	Activity
Occupational performance	Setting	Assessment
Occupational components	Skills	Autonomy

### 4. Building concept classification:

In this stage, we followed the Top-down strategy to construct the high level of concepts of the ontology. The top- down method helps in creating the basic relations

between concepts. The ontological hierarchy is developed based on the main components of the domain knowledge such as:

- Occupational Therapy Components
  - Therapist
  - Client= patient
    - Individuals
    - Groups
    - Organisation
  - Therapy
    - Therapy Action
      - Referral or reason for contact
      - Information gathering
      - Initial assessment
      - Problem Formulation
      - Goal setting
      - Action Planning
      - Treatment Implementation
      - Ongoing Assessment
      - Evaluation
      - Outcome Measurement
  - Therapy Method
  - Performance Area
    - Activities of Daily Living
    - Working and productive Activates
    - Play Activities
  - Performance Components
    - Sensorimotor Component
    - Cognitive Integration
    - Psychosocial Skills and Psychosocial Components
  - Performance Contexts
    - Temporal Aspects
    - Environmental Aspects
  - Action
    - Internal influence
    - Philosophy
    - Beliefs
    - Values
    - Ethics
    - Goals
    - Key Concepts
    - Skills
    - Responsibilities
    - External Influence
    - Personal Experience
    - Education
    - Academic trends
    - Social and culture environment
    - Social context
    - Working Context
    - Historical

However, to attend to specific problems the relationships should be identified that provide more precise details; in OTO ontology, many taxonomic relationships

have been built, e.g., Is-A, hasA. Also, some relations among concepts are non-taxonomic relations used to present within the relation concept.

Therapists should have professional beliefs and values, about the nature of people, the nature of health, and beliefs about the nature and purpose of OT. OT ontology provides clear relationships between Clients, whether individual, group or organisation, each of which has to be influenced by internal and external factors.

Meanwhile, everyone has a history, experience, language, social and culture, physical, thoughts, beliefs, values, aspirations, needs, problems, interest, and abilities. More relationships are depicted in Figure 4.

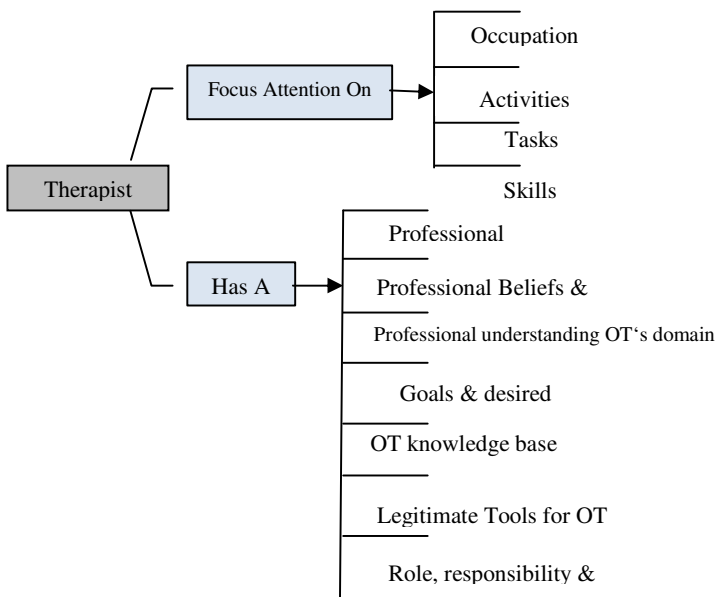


Figure 4. Relationships in OTO ontology

In the formal model of OTO ontology that covers the whole domain, the main classes are categorised based on fundamental considerations about the role concepts in the area. The Ontology is implemented by organising concepts according to is-A, part-of and hasA relations with axioms.

That gives specific definitions of these concepts. A fragment of the ontology is presented in Figures 5 and 6.

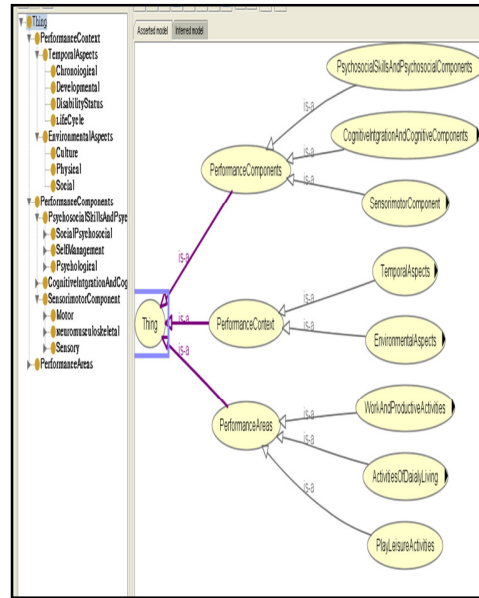


Figure 5. OTO ontology in Protégé

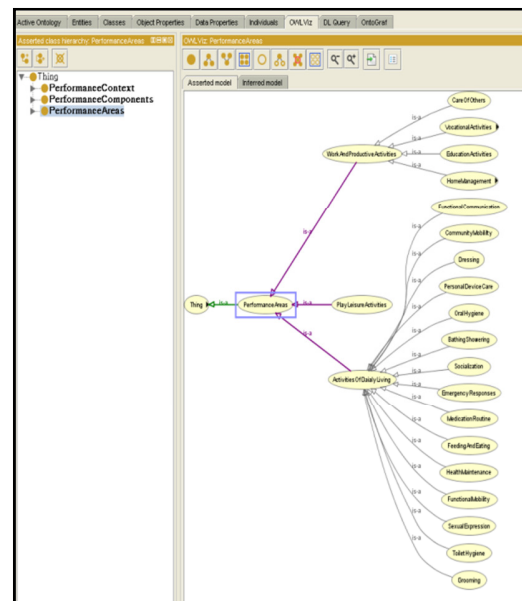


Figure 6. OTO ontology in Protégé

## V. DISCUSSION AND EVALUATION

The OTO ontology is based on IE techniques for extracting the main concepts in the domain. Our extraction of OT concepts using JAPE grammar and regular expression based on the GATE developer for automated IE provides significant results. The main idea behind using JAPE and regular expression is to identify OT terminology as tokens, for example Occupational Therapy, Activity and daily living, from a large text. The term identification relies on



looking up a list of OT terms from the Gazetteer. For example, we could look up collecting information, analysis of information, interpreting information or Social norms, social expectation, cultural norm, cultural expectation. These concepts can be collected to be the main component of the OT glossary and to structure in semi-formal hierarchy before creating the computational model of the OTO ontology.

We extracted the OT concepts from a corpus of 300 documents, obtained specifically for this purpose. We ran the ANNIE application, using document reset, Tokenisor, sentence Splitter, Gazetteer, POS tagger, JAPE transducer and Orthomatcher. The annotation set that appeared in the display panel, and the concepts are highlighted in the annotation default; each annotation has a different colour after running ANNIE and highlighting the matching concepts. The results show that our approach successfully annotates concepts. We recalled 541 of the *Occupation* concept, 275 of the *Therapy* concept and 35 of the *Habit* concept. Each annotation starts from a specific point and ends at a different point based on how many tokens it has. The *Occupation* concept starts at point (557) and ends at (566), while the *Therapy* concept starts at (624) and ends at (636), with its features {major Type=concept}.

In this study, the data were evaluated based on evaluation metrics for precision, recall and the F-measure, which is common metrics in IR field that defined as follows:

$$Precision = \frac{Correct + \frac{1}{2} Partial}{Correct + Spurious + Partial}$$

$$Recall = \frac{Correct + \frac{1}{2} Partial}{Correct + Missing + Partial}$$

$$F - Measure = \frac{(\beta_1 + 1)P * R}{(\beta_2 P) + R} \quad (4)$$

The statistics of the corpus show that the pattern matching of OT concepts based on the lookup OT list was 403, correct concepts and accuracy were generally higher, and there were no partially correct results (0), or missing false positives, as illustrated in figure 7

Correct:	403	Recall	Precision	F-measure
Partially correct:	0	Strict:	1.00	1.00
Missing:	0	Lenient:	1.00	1.00
False positives:	0	Average:	1.00	1.00
Statistics		Adjudication		

Figure 7. The Accuracy results

The OTO ontology model represents OT therapist searching needs, and has potential to help social studies researchers find primary sources. The OTO ontology followed Methontology [17] ontology methodology

engineering as a general framework to construct the ontology model, and it was evaluated based on ontology quality criteria to ensure its clarity and completeness.

## VI. CONCLUSION AND FUTUREWORK

### A. Achievement

The development of OTO ontology is a stage towards creating a sharable and reusable OT system. Ontology is a formal model for therapists and social staff organising vision in the information hyperspace of the domain knowledge. This paper has described a method using NLP techniques to extract concepts for the purpose of developing OTO ontology. Furthermore, the development of the IE system should save time and effort in labelling the most common concepts. In total, we extracted 664 concepts that are classes of the OT, and 650 subclasses making up the main components of the ontology skeleton. The IE technique can be applied to many different formats, such as XML, HTML documents, URLs or emails.

### B. Future work

Ontology is at the heart of the semantic web. It defines concepts and relations that make global interoperability possible. In future work, we plan to enhance more concepts to develop OTO, to be applied in specific applications to solve specific problems related to the OT domain.

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