PurposeNet: A Knowledgebase Organized Around Purpose

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Abstract. We show how *purpose* can be used as a central guiding principle for organizing knowledge about artifacts. It allows the actions in which the artifact participates to be related naturally to other objects. Similarly, the structure or parts of the artifact can also be related to the actions.

A knowledgebase called *PurposeNet* has been built using these principles. A comparison with other knowledebases shows that it is a superior method in terms of coverage. It also makes it possible for automatic extraction of simple facts (or information) from text for populating a richly structured knowledge-base.

An experiment in domain-specific question-answering from a given passage shows that PurposeNet used alongwith scripts (or knowledge of stereotypical situations), can lead to substantially higher accuracy in question answering. In the domain of car racing, individually they produce correct answers to 50% and 37.5% questions respectively, but together they produce 89% correct answers.

Keywords: Ontology, Semantic Knowlegdebase, Information Extraction, OWL, Question-Answering

1 Introduction

There is a need to represent knowledge for a variety of applications, ranging from natural language processing to reasoning in sciences, education, business, social science and humanities. This requires Knowledge Representation (KR) schemes, as well as good ways of organizing knowledge.

KR schemes and inference methods have received a great deal of attention. This has resulted in several effective schemes which are strong as well as have efficient and powerful inference methods. Notable among them have been Sowa (1984), (2002), (2005) and Bharati et. al (1987), (1991), (1995).

Besides the KR schemes, there is also a need to work out the organization of knowledge. The question naturally arises as to what principles should be used to organize knowledge, namely, what knowledge should be put in, and how would parts of that knowledge relate with other parts of knowledge? For example, if the domain of transport needs to be described, how should the different elements starting from car and trucks and going to repairs and roads, be organized?

The answer lies in recognizing that there are principles underlying the organization. Once these are understood, it becomes easier to relate different parts of knowledge with each other. Such knowledge can then be represented in a suitable KR scheme.

We have used purpose as an organizing principle in our work. This principle has been applied primarily to artifacts or manmade objects. It has been developed and used extensively in the Indian philosophical tradition. Objects are described in terms of four major types of attributes: rup, gun, svabhav, dharm.

Dharm is that property which is intrinsic (essential) to the objects in the category, and helps distinguish the category from other categories. Dharm is given by its purpose. For example, for a car, its dharm or purpose would be to transport (a small number of) people from one place to another on land.

Svabhaav refers to those attributes which the object shares with objects of the same class and which it does not share with other classes. For example, Car shares attributes with other machines, but does not share attributes with living beings.

Rup (literally meaning, form) refers to those attributes which can directly be perceived by our sensory organs. For example, rupa of car would be its shape, colour, weight, etc. Gun refers to properties that are not perceived directly but indirectly such as load carrying capacity, etc. dharm and gun are performative, where assvabhav and rup are non-performative (though they are essential for performance).

While building PurposeNet, a knowledgebase, we have used purpose as the primary principle of organizing knowledge. We note that the dictionary uses the same idea to give meanings of words. Let us take some examples from popular resources such as WordNet (Miller et. al, 1990), Wikipedia (Wikipedia, 2004) and Cambridge dictionary (http://dictionary.cambridge.org/ dictionary/american-english/).

WordNet defines the artifacts "fork", "bomb" and "knife" in the following manner:

1. Fork - cutlery used for serving and eating food.
2. Bomb - an explosive device fused to explode under specific conditions.
3. Knife - edge tool used as a cutting instrument; has a pointed blade with a sharp edge and a handle.

In Wikipedia articles on artifacts, the first sentence generally describes the artifact as exemplified below:

1. Chair – A chair is a raised surface, commonly <u>for use by one person</u>.
   Wall – A wall (from Old English weall) is a vertical structure, usually solid, that <u>defines and sometimes protects an area</u>.
2. Football - A football is an inflated ball used to play one of the various sports known as football.

Cambridge dictionary has the following entries:

1. Telephone – A device <u>for speaking to someone</u> in another place by means of electrical signals
   Brush – Any of various utensils consisting of hairs or fibers arranged in rows or grouped together, attached to a handle, and <u>used for smoothing the hair, cleaning things, painting, etc.</u>
   Rack – A frame, often with bars or hooks, <u>for holding or hanging things.</u>

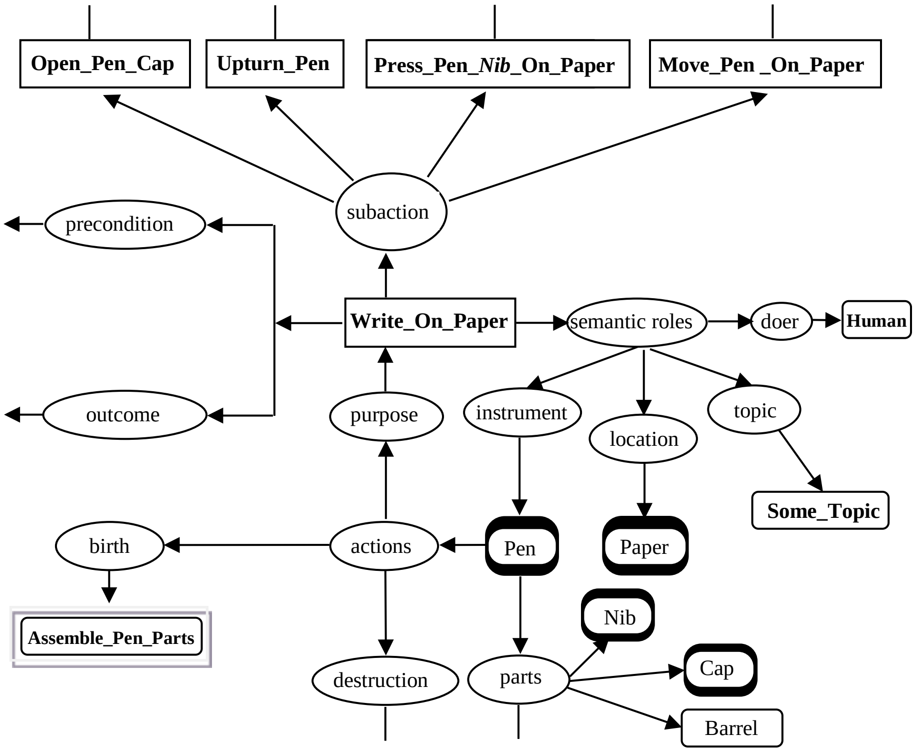

Fig.1. Illustration of importance of Purpose as a basis for knowledge representation.

All the nine entries cited above are defined in the form "an *X*<is a *Y*><with purpose *Z*>", where, *X* ={Fork, Bomb, Knife, Chair, Wall, Football, Telephone, Brush, Rack}, *Y* = {cutlery, explosive device, edge tool, raised surface, vertical structure, ball, device, utensil, frame}, *Z*={to sit on, that protects an area, to play, for throwing, for holding, …}. Thus, purpose is very significant information about artifacts. An artifact is made in order to serve one particular purpose. The various characteristics and activities associated with an artifact depend upon the purpose for which it is created.

As one would have noticed, the purpose of an object is given in terms of an action that the object helps accomplish. The object also has a structure, i.e., is made up of parts which are put together in well-defined way. The structure is related to the purpose of the object, namely, the structure helps accomplish the purpose.

In the case of a pen, for example, the purpose is to write on paper. The Pen has a thin and cylindrical shape for a comfortable gripping while used for writing. It has many sub-parts, such as Barrel, Nib, Feed and Cap, which together help carry out the action of putting marks on paper. The action can be broken into sub-actions which relate to the parts, where each part helps in carrying out some sub-action(s). Barrel holds Ink, Nib allows Ink to pass through and Cap prevents the Ink from drying. Therefore, when Ink-Pen is made, it is an assemblage of the aforementioned components and we know why the components are in the way stated. Each of them helps in fulfilling the central purpose of Pen, which is, writing.

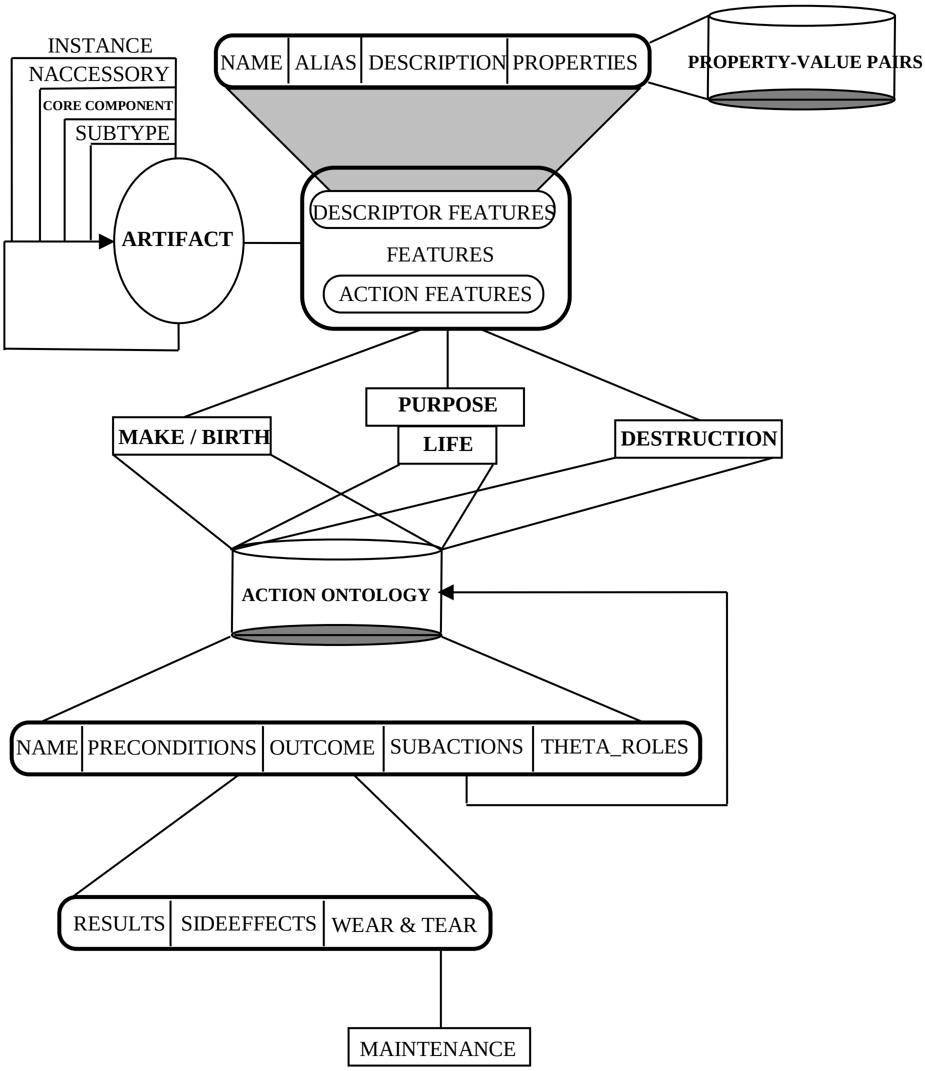

Fig. 2. Architecture of PurposeNet

If we look at the life cycle of an entity, we find that it has three major phases: creation, life and destruction. The purpose of an artifact is fulfilled at the second phase of life cycle, namely, when it has life. Therefore, at this phase, the artifact gets associated to other entities without which the purpose cannot be fulfilled. For example, a human being is an 'agent' who uses 'Pen' as an 'instrument' of writing. The writing is done on a smooth surface, for example, Paper. Ink is a requisite for writing. Thus, the artifact Pen is now related to the artifacts Ink and Paper as well as a 'human agent' without whom the action of 'writing' will not take place. There might be a change of state, for example, a Pen-Barrel can break; Ink gets over after a period of time. Finally, in the third phase of the life cycle of the artifact, it undergoes destruction. For example, ‘Pen’ undergoes destruction and gets converted to another entity, such as the reuse of metal parts for making of some other entity, such as ‘Staple Pin’. It is therefore possible to engineer a knowledgebase of entities based on the characteristics activities and states of entities. Whereas object-oriented paradigm suggests that objects should be the central focus for engineering knowledgebase, our observations on entities suggest that entity-based knowledge cannot be complete unless it is focused on the purpose of entities and the actions that the artifacts are involved in.

We formally define PurposeNet in the following terms:

PurposeNet is a knowledgebase of artifacts with its properties, relationships and actions in which it participates with purpose as the underlying design principle.

2 Architecture of PurposeNet

PurposeNet has the artifact as its primary focus for organizing knowledge. Artifacts are fully described by its features and relationships with other artifacts. Two kinds of features have been postulated for the task: descriptor features and action features. The details of these features are given in section 2.1. Artifacts can also be described by the company it keeps, i.e. its relation with other artifacts as illustrated insection 2.2. The architecture of the PurposeNet is shown in the figure 2.

2.1 Features

The various distinct properties of an artifact are called its features. These features may be morphological such as the physical state of the artifact, its size, shape, magnitude and so on. The features may also be physiological like make, wear and tear, activities it performs, and so on. Based on whether the feature is morphological or physiological, we subcategorize features into the *descriptor features* and *action features*.

Descriptor Features.

The descriptor features of PurposeNet have three constituents that are found in WordNet as well, viz., Name, Alias and Description. SUMO has one attribute *Internal* that contains some properties which are similar to PurposeNet *descriptor features*. However SUMO properties are limited to olfactory, visual, texture and taste, with no further refinement. The descriptor features of PurposeNet have been prepared after a study of texts of *Nyaya-Vaisheshikadarshana*(Prasastipada(1977), Singh(2001),Kulkarni(1994)) and others (Isvarkrsna(2007), Nagaraj(2003), Cowell(2001)).

Descriptor Feature	**Definition**	**Value**
Color	The property possessed by an object of producing different sensations on the eye as a result of the way it reflects or emits light	Red, Blue, Green, Cyan,Indigo, Orange, Pink, Black, White, Any
Constitution	The material with which an artifact is made of	Metal, rubber, wood, foam, plastic, glass
Shape	The external appearance of an artifact	Cubical, Oval, Triangular, Circular, Spherical, Aero, any
Size	The amount of space occupied by the artifact	Microscopic, very small, small, medium, large, any
State	The physical state in which the artifact usually exists	Solid, liquid, gas

Table 1. Descriptor Features and their description

From the complex set of properties, we have selected twenty five based on the ones most suitable for all artifact types. Also, we have added properties of significance such as Standard Capacity, Standard Weight, and, Physical State to enable a more comprehensive representation of information about artifacts. The possible values that can be taken by these properties (qualitative) have been extracted from various sources, including Wikipedia, Alani and Brewster(2006), Helmhotz (1970), Sunder Rao (2003), and Gayatri Devi (2007). A brief description of some properties in *descriptor features* is given in table 1. Comprehensive Descriptor feature list is given in Appendix.

The value of some descriptor properties with respect to the artifact Car is given in table 2:

SNo	**Decriptor_Feature**	**Value**
1	Name	Car
2	Alias	Automobile
3	Description	A type of motor vehicle used to transport people.
4	State	Solid
5	Shape	Aerodynamic

6	Color	Any
7	Constitution	Metal
8	Size	Moderate_Size

Table 2. Values of Descriptor properties for the artifact Car

Action Features

Since the very need for an artifact is to serve some purpose in the human environment, it is understood that every artifact is associated with some actions. The various activities associated with an artifact constitute its Action Features. This categorization has been developed based on the various stages in the Lifecycle of an artifact. The first stage of an artifact is its Make or Birth. It is then prepared for the first-time use, after which it reaches the purpose-serving stage, i.e., Life. Here it may be prepared again for reuse or may be in the general or repair-related maintenance stage. From here, the artifact again goes back to the purpose-serving stage. After one ormore iterations of the purpose-serving stage, the artifact becomes no longer usable, which is when it is in the Destruction stage, and is therefore a last stage activity. Its individual parts are recycled and it becomes the basis for the birth of the same or another category of artifact. The various action features are accordingly classified primarily as – make actions, purpose-serving actions, and, actions after destruction. The secondary actions are first-time preparation-before-use actions that makes an artifact usable and the trio of subsequent preparations before use actions, general maintenance and repair maintenance actions that allow for subsequent usage of an artifact. Table 3 shows these actions for Transport_using_Car artifact.

SNo	Action Feature		Value
1	Make/Birth		1. Integrate(Car_Interior_Parts) 2. Integrate(Chassis and Car_Body)
	1a.	First-time-Preparation before use	1. Fill(Car_Fuel) 2. Test(Car_Pedals) 3. Test-Drive(Car) ….
2	Life - Purpose		Transport things
	2a.	Subsequent preparation before use	1. Check(Fuel) 2. Test(Car_Pedals) 3. Check(Rear_View_Mirror) …...
	2b.	Repair Maintenance	1. Repair(Car_Engine) 2. Repair(Car_Ignition_system) 3. Repair(Car_Pedals) 4. Repair(Car_Door) ….
	2c.	General Maintenance	1. Wash(Car) 2. Oil(Car_Engine)

			3. Oil(Ignition_System) 4. Fill(Car_Tyre)
3	Destruction		1. Car_Engine - Recycled-to-metal 2. Car_Tyre - Recycled-to-fuel-and-oil 3. Car_Chassis - Recycled-to-another-Car 4. Car_Seat - Reused-in-another-Car

Table 3. Table showing all the Action-features of a Car

Every non-primitive action can be fully described using a quadruple consisting of its preconditions, outcomes, subactions and semantic roles. We call this Quadruple as the action frame. Every primitive action can be described using the same frame as above, minus the subactions. This description remains unchanged irrespective of the broad category into which the action belongs – i.e., whether it is birth or make action, or action related to life. The action frame places a formal structure on the Action features (Kiranmayee et al., 2011).The action frame for a sample action, namely 'transport thing', which is the purpose of the artifact Car is given in table 4.

Artifact: Car:: Purpose – Transport_Thing			
No	**Action Frame Element**		**Value(s)**
1	Precondition		1) Exists_Car_at_Source 2) Exists_Thing_Near_Car
2	Out-come	Result	1) Change_Position (Thing)
		Side Effect	1) Change_Position (Car) 2) Change_Position (Driver)
		Wear-and-tear	1) Wornout(Engine) 2) Wornout(Tyre)
3	Subactions		1) Load(Thing) 2) Drive(Car) 3) Unload(Thing)
4	Theta Roles		1) Theme – Thing 2) Source – Place 3) Destination – Place 4) All other Roles – Null

Table 4. The Action Frame for the action *transport*_thing_from_Source_To_Target

2.2 Relations

An artifact can also be described in terms of its association with other objects in the world. For example, objects that come to our mind when we think of the artifact Car might be the following: engine, wheel, steering, gear, seat, petrol, diesel, road, petrol pump, car window, music system, rear view window, car body and so on. The relations of these artifacts with car exist at different planes in terms of purpose that the Car is used for. The primary purpose of Car as shown in table 3 is 'transport things from one place (*X*) to another place (*Y*)'. In order to fulfill the action of transporting, a Car needs to move from *X* to *Y* and we call the action 'drive'. For 'drive' action to take place, following parts of Car which claim to have a purpose of their own, is essential: Engine, Wheel, Steering, Gear. Such components are called Core Component. Rear view window is also part of Car but it is useful for some specific movement of car (i.e., when the car moves back). Such components are called purpose-serving-accessory in contrast to non-purpose-serving-accessory such as AC, music system which are parts of Cars but are not directly related to Car driving. Other kind of artifacts such as petrol, diesel, road are directly related to driving even though they are not part of Car. Such artifacts are related to Car with in terms of a relation called Naccessory. Apart from these relations, there exist the usual subtype relations between an artifact and its specific types. The following figure demonstrates various relations and example cases for the artifact Vehicle:

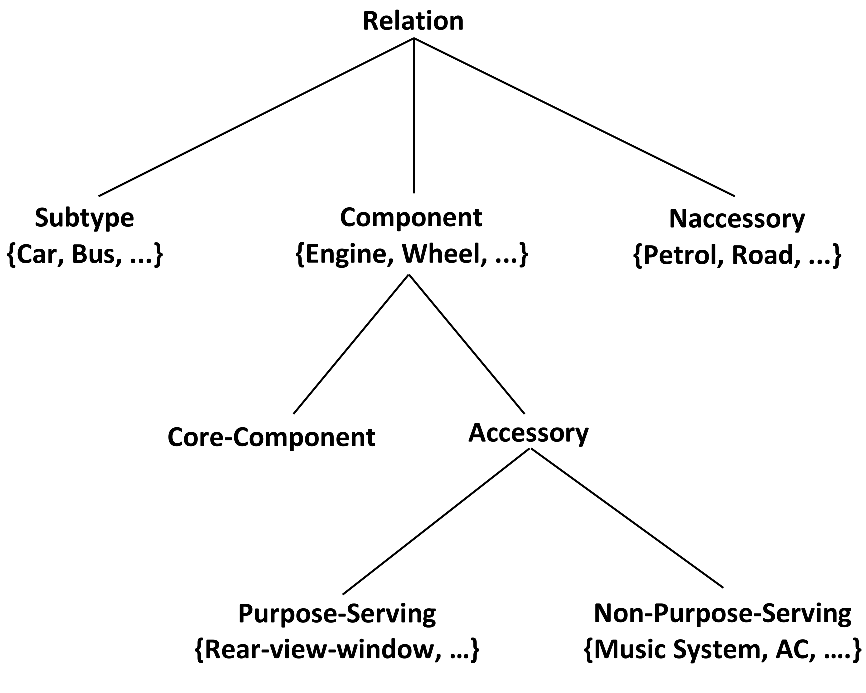

Fig.3. Relations describing an artifact

3 Implementation

The best possible design to represent our architecture of PurposeNet is object-oriented and top-down methodology. The PurposeNet knowledge base has been implemented using the concept of Ontology. Ontology is a formal explicit description of concepts in a domain of discourse, properties of each concept describing various features and attributes of the concept, and restrictions on slots. Ontology together with a set of individual instances of classes constitutes a knowledge base (Noy, 2001). Ontology helps us develop the Semantic Web, which is a vision for the future in which information is given explicit meaning on the web, making it easier for machines to automatically process and integrate information. We have chosen OWL to implement our knowledgebase.

3.1 Statistics of PurposeNet Implementation

The active ontology for purposenet in Transport domain has an Artifact count of 3678 (Car_Door, Car, Car_Hinge ...), general property count of 87 (Color, Shape, …, Birth, Processrel, ...), data property count of 8 (capacity, number, ...), Instances count of 264 (Audi_A4, BMW_6_Series, Chevrolet_Tahoe, Daewoo_Matix, ...), and SubClasses count of 8045 (Car_Rear_Seat, Car_Passenger_Seat, ...). The same is developed Semi-automatically by Domain Experts. The statistical data is given in table 5.

Metric	Count (Transport Domain)
Class count	3678
Object Property count	87
Data Property count	8
SubClassOf axioms count	8045
SubObjectPropertyOf axioms count	76
Individual count	264
Annotation Assertion axioms count	1918
Class Assertion axioms count	258
Number of Assertions	1000 000

Table 5. Statistics of implementation of PurposeNet in OWL

4 Comparison with Other Ontologies

We evaluate PurposeNet from two perspectives:

1. Quality Evaluation in terms of various metrics as tabulated in table 6;
2. Estimation of how well the ontology represents the given search terms in the context of ontology search engine.

4.1 Metric based Comparison

Three popular ontologies were selected for a metric-based comparison with PurposeNet to evaluate its quality. The three ontologies selected are – the general Semantic Web Technology Evaluation Ontology (SWETO) (Meza et. al, 2007), Glycomics Ontology (GlycO) (Satya et. Al, 2005), and, TAP (Guha and McCool, 2003).The results shows that PurposeNet scores much higher than all the other ontology in terms of Class Importance (which determines the importance of a class by the ratio of number of instances connected to the subtree attached to a class Ci in comparison to the total number of instances (I) in the ontology, showing how many classes play a central role compared to other classes). The completeness check (for populating relations, showing the percentage of relation slots filled in by values, thereby determining how well the ontology can be utilized) yielded incompleteness for 7 of the 443 classes defined in the Car subtree.

SNo	Metric	SWETO	TAP	GlycO	PurposeNet
1	Classes	44	6,959	361	3678
2	Relations	101	25	85,637	95
3	Instances	813,217	85,637	660	264
4	Schema Relationship Richness	NA	NA	NA	0.185
5	Schema Inheritance Richness	NA	NA	NA	1.68
6	Schema Attribute Richness	NA	NA	NA	44
7	Class Richness	59.1	0.24	48.1	0.029
8	Class Connectivity	8	6	10	4
9	Class Importance (max. value)	59	31	18	100
10	Cohesion	NA	NA	NA	881
11	Class Relationship Richness (max. value)	NA	NA	NA	100

Table 6. Comparative representation of various ontology metrics

4.2 Comparative rank scores of PurposeNet and akt ontology for browser-retrieval

The efficiency of an ontology can also be determined based on the rank search engines on the web gives. Browser-wise, ontologies are usually ranked based on three criteria – user popularity, evaluation tests and structural criteria (Gangemi, 2006). An ontology may be ranked structurally based on CMM, DEM and SSM (HarithAlani and Christopher Brewster, 2006). We have used the reference ontology of the akt (Advanced Knowledge Technologies) project on extraction and use of knowledge (Motta, 2001). The observations with respect to the various ranking measures in PurposeNet in comparison to the best ontology (ranked 1) outcomes obtained by Alaniet. al. (2005) with respect to the akt reference ontology is tabulated in table 7 below. It is observed that the akt ontology performed better with respect to the CMM (Class Match Measurement, the number of concepts in the ontology that either match (M) or contain the search term (C), that determines how many search terms exactly match with terms in our ontology, that presents the certain degree of detail in the representation of the knowledge concerning that concept) as well as DEM scores(Density, the number of superclasses (U), subclasses (S), attributes (A) and siblings (I) associated with the individual concepts in the ontology), whereas, PurposeNet had a better SSM score(Semantic Similarity, how close related terms are placed in the ontology, where, ontologies that position concepts further away from each other are less likely to represent the knowledge in a coherent and compact manner. It is measured by the path distance between the two different concepts in question), favoring its faster representation on Swoogle.

Ontology	CM M	DEM	SSM	Total Score
PurposeNet	0.786	0.589	0.413	0.596
akt reference ontology	0.833	0.632	0.250	0.571

Table 7. Comparative rank Scores of PurposeNet ontology and akt ontology

5 Purpose Detection and Extraction

The method of knowledge discovery by manual extraction of data and manual building of PurposeNet ontology is quite exhaustive as several experts are required to put in hours of browsing to find the data corresponding to the concerned features and to incorporate it. This also leads to a slow progress in the creation of a knowledge base that was supposed to finally have a size of a million artifacts. We follow a two-step process for the extraction of data from the web. The first task is to find an appropriate method to detect the presence or absence of a relation. The second step would be to extract the relation from the text that is known to contain the semantic relation. This methodology has been applied on the purpose relation as a case study for generalization across all other relations in PurposeNet.

5.1 Purpose Detection

Sentences containing particular relations have specific structure(s) in terms of a key word or words in a particular order. We select WordNet as the corpus for our work. The principle behind the selection of the WordNet as the corpus is the observation that 70% of the WordNet corpus contains purpose data. We perform automatic detection by transforming the problem of relation detection to a binary classification problem. There are many supervised as well as unsupervised methods of classification that have been graded equally well in other domains. Some of these are the Typed Dependency Parse (Catherine et. Al, 2006), Decision tree forest (http://www.dtreg.com/treeforest.htm), the Naïve Bayes method (Bayes et. Al, 1763), the kernel based Neural Network approach and the more popular Support Vector Machine (Vapnik et. al, 1995) based approach. A comparative study of these various methods of detection of purpose data in table 8 shows that the typed dependency and simple decision trees method of detection gives maximum precision over others. A comparison of the various recall values shows that the typed dependency method has the highest recall. Hence, we suggest the typed dependency method as the most favorable among all methods of purpose detection.

Sno	Method	Precision	Recall	F-Measure
1	Typed dependency	0.84	0.68	0.751
2	Simple Decision Tree	0.83	.67	.74
3	Decision Tree Forest	0.679	0.644	.661
4	Bagging	.755	.619	.68
5	Naïve Bayes	.7	.638	.668
6	Bayes Net	.699	.639	.668
7	RBF Neural Network	.679	.595	.634
8	SVM	.694	.639	.665

Table 8. Comparison of efficiencies of various automatic purpose detection methods

5.2 Purpose Extraction

Our target is to extract the artifact whose purpose is known to be available in text. This section explains the three methods used for extraction of purpose from text: a. Clue Based Extraction, b. Extraction using Typed Dependency Parse and c. Extraction using Surface Text Pattern.

Method	Precision for extraction of (artifact, action) pair given purpose-containing sentences
Purpose clues	69
Surface Text Patterns	88
Typed dependency Parse	98.1

Table 9. Comparativeperformancemeasuresof various purpose extraction methods

Table 9 shows a comparison of the performance of the three methods. The results show that Typed dependency method performs well in extraction of (artifact, purpose) pair. Surface Text Patterns perform well too, considering that the entire web is its corpus, vis-a-vis the other two methods which used offline corpora.

6 Applications

PurposeNet has a number of applications in various reasoning tasks, including Question Answering (QA), provision of online help in web pages, aiding expert systems and broadly in Natural Language Understanding. We describe an application that we have built to evaluate our ontology.

6.1 Domain Specific Question Answering

In this application, a passage is given as input to the automated QA system and the output to a set of questions is obtained. The same task is given to an average car user and the two outputs are compared.

Design.
We have built four alternative modules and each module uses a different resource for producing the answer. Module 1 uses only the passage from where the answer is to be retrieved. Module 2 uses passage and script; Module 3 uses passage and PurposeNet and Module 4 uses passage, script and PurposeNet. We have used a racing car text to test the modules. We have developed a script for racing car. A script (Schank, 1974) is a structure that prescribes a set of circumstances which could be expected to follow on from one another. PurposeNet contains information which is true for an artifact in all circumstances and a script is a structure that prescribes a set of circumstances which could be expected to follow on from one another. It is similar to a thought sequence or a chain of situations which could be anticipated. The components of the script for the text are:

1. Entry Conditions – the conditions that must be satisfied before events in the script can occur.
2. Results – Conditions that will be true after events in script occur.
3. Props – Slots representing objects involved in events.
4. Roles – Persons involved in the events.
5. Track – Variations on the script. Different tracks may share components of the same script.
6. Scenes – The sequence of events that occur. Events are represented in conceptual dependency form.

The theme of car racing can be segmented into 5 scenes: 1. Arranging track; 2. Prepare for the race; 3. The race; 4. The finish; 5. The victory lap.

Script:Car Race	Track: American Car Race – A Win
Props: R = Race Car T = Race Track F = Checkered Flag G = Shot gun	*Roles:* D = Car Driver S = Spectator Q = Pit team O = Organizer

P = Petrol L = Finish Line	
Entry Conditions: • T exists • R exists • D exists	*Results:* • D has more money. • D has won the race. • R has less P.
Scene1: Arranging the track • O sprinkles T • O grinds T • *(go to scene 2)*	*Scene 2 : Prepare for Race* • O checks T • O signals R line-up • D line-up R • D test-drive R • O signals start race with G • *(go to scene 3)*
Scene 3: Race • D accelerates R • D steers R • *(go to scene 4)*	*Scene 4: Finish Race* • D crosses L. • *(go to scene 5)*
Scene 5: Victory Lap • D gets F. • D waves F. • D drives on T.	

Table 10. A simplified racing script

The complete Script could be described in Figure above.

Result.

Experiments were conducted on answering questions where both the passage and the questions were given as input to each of the 4 modules and compared with theoutput of human users. The results show that the comprehension passage alone yielded 6% of the answers. These were Queries that were directly related to the story in the Comprehension passage, such as *–Did the drivers test-drive?* 10% of the queries related to Car race are answered by PurposeNet alone. These were technical Queries related to Cars such as – *How did the pit Team repair Clint's car tyre?* 27 % of the queries are answered using Scripts alone. These pertained to the sequence of events in a stereotypical Car race, such as – *What is the connection between waving the checkered-flag and the victory-lap?*

SNo	Resource used to obtain Answer	No. of Queries correctly replied (/30)	Efficiency (/30) in %	% of answers given using this resource
1	Comprehension Passage	2	6	12.5
2	Script	8	27	50
3	PurposeNet	6	20	37.5
4	PurposeNet + Script	14 + 3	57	89
	Total	19	—	—

Table 11. Comparative results of Queries answered by AOM Script Applier using various resources

7 Conclusion and Future Work

The paper presents the conceptual base, architecture and implementation of a semantic knowledgebase called PurposeNet with an evaluation performed on it comparing it with some other available knowledgebase. Building an exhaustive knowledgebase is a laborious and intense task, it needs human expertise and it needs good web data processing tools so that information from the web can be easily extracted in order to build the knowledgebase semi-automatically. In order to maintain the quality of the resource, we have, till now, manually created the knowledgebase. Nevertheless, we understand that creating such huge resource completely in manual mode would be a time-consuming work. We have noticed that artifact related information which is useful for our knowledgebase is available in various resources such as WordNet, Wikipedia and other web corpora. We have conducted a few experiments on detecting and extracting purpose of artifacts from web corpus and reported the result in this paper. Experimental results in domain-specific question-answering have produced promising results.

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Appendix

SNo	Description Feature	Definition	Values

1	Color	The property possessed by an object of producing different sensations on the eye as a result of the way it reflects or emits light	Red, Blue, Green, Yellow, Cyan, Indigo, Orange, Pink, Black, White, Any.
2	Constitution	The material with which an artifact is made up of	Metal, Rubber, Wood, Foam, Plastic, Glass, etc.
3	Fluidity	The physical property of a substance that enables it to flow	Fluid, Nonfluid
4	Heaviness	The comparative weight of an artifact	Heavy, Light, Moderate Weight
5	Inertness	The reactivity of an artifact with the substances around it	Inert, Alkaline, Acidic
6	Mobility	The movement of an artifact during the performance of its target task	Mobile, Immobile
7	Oiliness	The presence of oil on the surface of the artifact	Oily, NonOily
8	Position	The position of an artifact vis-à-vis the artifact it is embedded in	Above, Below, Inside, Left_Of, Right_Of, In_Front_Of, Behind
9	Shape	The external appearance of an artifact	Cubical, Spherical, Circular, Oval, Triangular, Aero, any
10	Size	The amount of space occupied by the artifact	Microscopic, very small, small, medium, large, any
11	Sliminess	The sticky, slippery property of an artifact	Slimy, Nonslimy
12	Smell	The property of an artifact that is sensed by the nose	No odour, Weak, Very Weak, Strong, Intolerable
13	Smoothness	The property of having a surface free from projections or irregularities	Smooth, Rough, Sharp, etc.
14	Softness	The property wherein the artifact gets deformed on application of pressure	Soft, hard
15	Sound	Mechanical vibrations emitted by artifacts when they function	Silent, whisper, bearable_sound, unbearable_sound
16	Stability	Indicates whether the given artifact remains as it is or disintegrates into the environ-	Stable, Unstable

		ment	
17	State	The physical state in which the artifact usually exists	Solid, Liquid, Gas
18	Subtleness	Indicates whether an artifact is so slight that it is difficult to perceive	Subtle, Nonsubtle
19	Taste	Indicates the property of an artifact that is perceived by the tongue	Sweet, Sour, Bitter, Umami, Salty
20	Temperature	Indicates the temperature at which the artifact usually exists	Hot, Cold, Warm, Normal,, Cool
21	Transparency	The property of the surface of an artifact that allows a human to see through it	Transparent, Opaque, Semi-transparent
22	Std. Capacity	Maximum weight that this artifact can hold	….kgs, ….lbs,…ltrs
23	Std. Magnitude	Standard dimensions of the artifact	….metres
24	Std. Weight	Weight of this artifact	….kgs, ….lbs