The Use of Expert Systems for Semantic Reasoning in Service Robots

Jesus Savage, Julio Cruz, Reynaldo Martell, Hugo Leon, Marco Negrete and Jesus Cruz
Bio-Robotics Laboratory, School of Engineering
Universidad Nacional Autónoma de México (UNAM)

Abstract— This paper describes a semantic module included in a robotics architecture of a service robot. The architecture consists of several layers that controls the operation of service robots and a semantic module is included in the Knowledge Management layer.

Keywords: Service robots, Semantic Reasoning, Knowledge Representation, Expert Systems [1]

I. *Introduction*

In our robotic architecture, the VIrtual and Real roBOt sysTem (VIRBOT), the operation of our service robot, Justina, is divided in four general layers: Inputs, Planning, Knowledge Management and Execution, having each of them several subsystems, see Figure 1. This system has similar features presented in the INTERRAP agent architecture [1] The VIRBOT has a combination of basic artificial intelligence (AI) techniques, specifically the ones used in natural language understanding, with devices and technology developed in the last years. Natural language understanding is used in order that the a service robot interprets the language and then perform something. One of the main problems using natural language understanding is the representation of meaning. Once the application is defined we have a framework for defining the semantics. The robot's semantics are therefore instructions that allow it to carry out relevant operations.

II. Semantic Analysis

One way to represent the meaning contained in a sentence is by finding the relationships that exist within its components. During this process the main event describing the sentence and participants are found, determining the roles they play in the event, an under which conditions the events took place. Sometimes finding the verb sets the possible role and conditions in which the actions may occur. Then it is possible to associated to some verbs frames that need to be filled, these may represent the participants and their relationships.

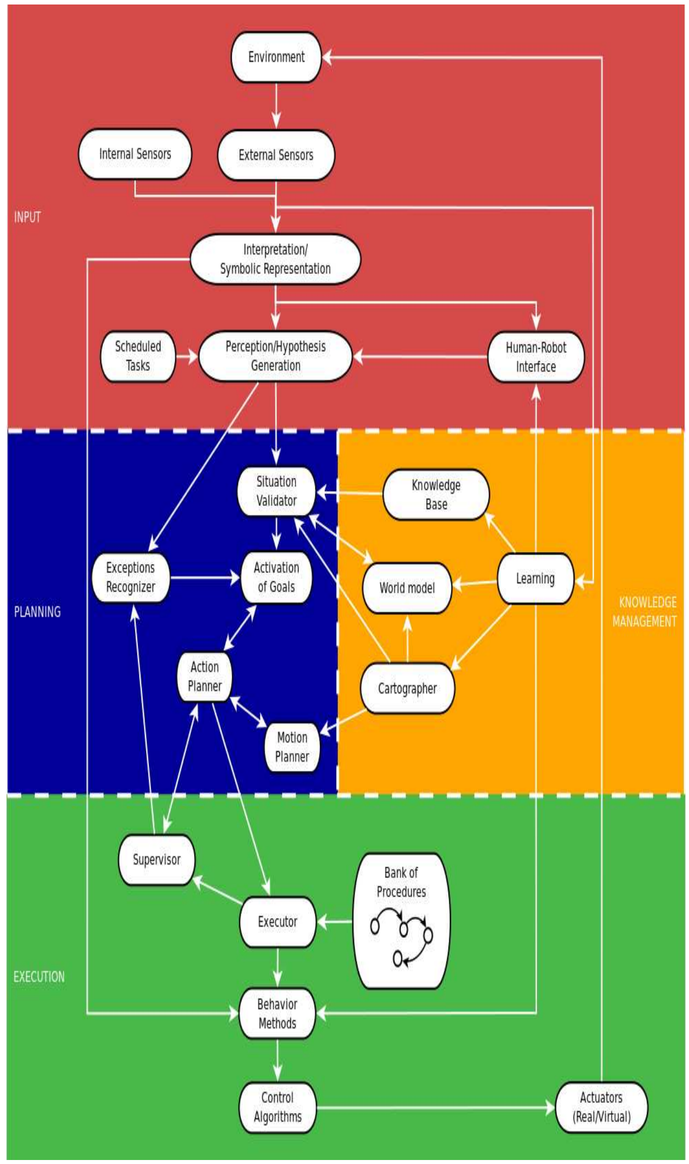

Fig. 1. The VIRBOT System

III. Conceptual Dependency

Conceptual Dependency (CD) is a theory, developed by Schank [2], for representing the meaning contained in sentences. This technique finds the structure and the meaning of a sentence in just one step. It is useful to represent sentences using this technique when there is not a strict grammar associated with the sentences, and also when the objective is to make inferences from them. The CD representation of a sentence is built using conceptual primitives, these represent thoughts and the relationships between thoughts. Using conceptual dependency facilitates the use of inference rules, because many inferences are already contained in the representation itself. There are sev-

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eral primitives to represent actions, for example two of the more commonly used are the following:

ATRANS: Transfer of an abstract relationship (e.g., give.)

PTRANS: Transfer of the physical location of an object (e.g., go.)

Each primitive represents several verbs which have similar meaning. For instance give, buy, steal, and take have the same meaning, i.e., the transference of one object from one entity to another. Each primitive is represented by a set of rules and data structures.

Basically each primitive contains the following components:

An Actor: He is the one that perform the ACT.

An ACT: Performed by the actor, done to an object.

An Object: The action is performed on it.

A Direction: The location that an ACT is directed towards.

A State: The state that an object is in, and is represented using a knowledge base representation as facts in an expert system.

For instance the phrase: "Robot, please give this book to Mary," when the verb give is found in the sentence an ATRANS structure is issued.

(ATRANS (ACTOR NIL) (OBJECT NIL) (FROM NIL) (TO NIL))

The empty slots (NIL) need to be filled finding the missing elements in the sentence. The actor is the robot, the object is the book, etc, and it is represented by the following CD:

(ATRANS (ACTOR Robot) (OBJECT book) (FROM book's owner) (TO Mary))

It is important to notice that the user could say more words in the sentence, like **"Now Robot, please give this book to Mary, as fast as you can"** and the CD representation would be the same. That is, there is a transformation of several possible sentences to a one representation that is more suitable to be used by an actions planner. These structures facilitates the inference process, but this inference problem is not solved, what it was done is to reduce the number of verbs into a small number of items, from which inferences can be done. CDs can be use for representing simple actions. It is also well suited for representing commands or simple questions, but it is not very useful for representing complex sentences. The conceptual dependencies technique were implemented in an expert system.

IV. Expert Systems

Much of the human problem solving or cognition can be expressed by IF THEN type production rules. Each rule corresponds to a modular collection of knowledge call chunk. The chunks are organized in loose arrangement with links to related chunk of knowledge, reasoning could be done using rules. Each rule is formed by a left side that needs to be satisfied (Facts,) and by a right side that produce the appropriate response (Actions.)

IF Facts THEN Actions.

When an action is issued by a rule it may become a fact for other rules, creating links to other rules. A system may use thousands of rules to solve a problem, thus it is necessary a special mechanism that will select which rules will be fired according to the presented facts. That mechanism is an Expert System "Engine". The Inference Engine makes inferences by deciding which rules are satisfied by facts, prioritize the satisfied rules, and executes the rule with the highest priority. In our system we use the open expert system CLIPS, that was designed by NASA with the specific purposes of high portability, low cost, and easy integration. It is designed to allow artificial intelligence research, development, and delivery on conventional computers. CLIPS provides a cohesive tool for handling a wide variety of knowledge with support for three different programming paradigms: rule-based, object-oriented, and procedural. In the VIRBOT system an expert system maintains a knowledge data base that represents the state of the world. The data of the humans interacting with the robot, of the objects and the locations is represented using facts that contain several slots with information related with them.

V. Actions Planner

The Robot is able to perform operations like grasping an object, moving itself from on place to another, finding humans, etc. Then the objective of action planning is to find a sequence of physical operations to achieve the desired goal. These operations are represented by a state-space graph.

In the previous example when the user says **"Robot, please give this book to Mary,"**:

(ATRANS (ACTOR Robot) (OBJECT book) (FROM book's owner) (TO Mary))

All the information required for the actions planner to perform its operation is contained in the CD and knowledge data base. Our system has been successfully tested in robotics competitions [3], as the RoboCup and Rocking [4], in the category @Home. In the following link is presented the qualification video for 2017 RoboCup @Home competition of our team Pumas, in which we present how our robot is able to interact with users and the environment updating its knowledge data base in real time, using vision and speech understanding: https://youtu.be/gPiU8NAiz7k

In this competition our robot was awarded as the best in Speech and Natural Language Understanding.

References

[1] *The Design of Intelligent Agents: A Layered Approach*, Muller, Jorg P,Springer-Verlag New York, Inc.1997.

[2] *Conceptual dependency and its descendants*, Steven L. Lytinen, Computers & Mathematics with Applications, 1992.

[3] *The Role of Robotics Competitions for the Development of Service Robots*, Jesus Savage, Marco Negrete, Mauricio Matamoros, Jesus Cruz, IJCAI'16, Workshop on Autonomous Mobile Service Robots", New York, USA, 2016.

[4] *RoboCup@Home* http://www.robocupathome.org
Rockin http://rockinrobotchallenge.eu/home.php