Report 1 – SHRDLU
Khoa Doan

1. What is SHRDLU?

SHRDLU is a natural language understanding program, created by Terry Winograd as part of his dissertation in 1972. *The system answers questions, executes commands, and accepts information in an interactive English dialog* with a user about a simple block a simple block world, consisting of basic toy objects such as blocks, cones, pyramids... Below is a part of the dialog that was used by Winograd in his demo of SHRDLU.

```
Person: PICK UP A BIG RED BLOCK.
Computer: OK. (does it)
Person: GRASP THE PYRAMID.
Computer: I DON'T UNDERSTAND WHICH PYRAMID YOU MEAN.
Person: FIND A BLOCK WHICH IS TALLER THAN THE ONE YOU ARE HOLDING AND
PUT IT INTO THE BOX.
Computer: BY "IT", I ASSUME YOU MEAN THE BLOCK WHICH IS TALLER THAN THE
ONE I AM HOLDING.
Computer: OK. (does it)
Person: WHAT DOES THE BOX CONTAIN?
Computer: THE BLUE PYRAMID AND THE BLUE BLOCK.
Person: WHAT IS THE PYRAMID SUPPORTED BY?
Computer: THE BOX.
Person: HOW MANY BLOCKS ARE NOT IN THE BOX?
Computer: FOUR OF THEM.
Person: IS AT LEAST ONE OF THEM NARROWER THAN THE ONE WHICH I TOLD YOU
TO PICK UP?
Computer: YES, THE RED CUBE.
Person: IS IT SUPPORTED?
Computer: YES, BY THE TABLE.
Person: CAN THE TABLE PICK UP BLOCKS?
Computer: NO.
Person: CAN A PYRAMID BE SUPPORTED BY A BLOCK?
Computer: YES.
Person: CAN A PYRAMID SUPPORT A PYRAMID?
Computer: I DON'T KNOW.
Person: STACK UP TWO PYRAMIDS.
Computer: I CAN'T.
```

SHRDLU was originally written in the Micro Planner and Lisp (MacLisp) programming language on a DEC PDP-6 computer and a DEC graphics terminal. The program was later improved to have a full 3D rendering of the SHRDLU's "world" at the University of Utah.

2. How SHRDLU works?

Winograd described that SHRDLU *“contains a parser, a recognition grammar of English, programs for semantic analysis, and a general problem solving system... It can remember and discuss its plans and actions as well as carrying them out... Knowledge in the system is represented in the form of procedures, rather than tables of rules or lists of patterns.”*

In SHRDLU, high-level commands or sentences, such as *"put a red Pyramid on top of the Blue block”*, are translated into commands for a simulated robot hand, which can only perform three basic actions:

MOVETO (a location), GRASP (a block), and UNGRASP (a block). This translation is non-trivial and is carried out in SHRDLU by a planner, which implements a technique call “backward chaining.” For example, in order to carry out the above command, SHRDLU must first search its knowledge base to choose which command is possible to satisfy it. In this case, it would find UNGRASP as a possible action, if the following three preconditions are satisfied: (1) the blue block has nothing on top, (2) the robot is holding the red pyramid, and (3) it is on top of the blue block. If the conditions are satisfied, the robot performs the UNGRASP action. On the other hand, suppose that (1) is not true, it would search for possible actions to satisfy it. This carries on until all actions can be performed and the concatenation of the actions is the sequence needed to achieve its initial goal. SHRDLU also keeps a history of its plan, so that later if it is asked a question such as *“Why did you pick up the green pyramid”,* SHRDLU can answer “So that the Blue block would be clear so I can put the red Pyramid on it.”

The internal representation of the Planner can be simply described to as in this example: “a red pyramid in a box” is represented as IS(x, pyramid) ^ COLOR(x, red) ^ IN(x, box). It was hard for a theory proving system at the time to understand what this means because the system carried out formal procedures on symbols without understanding what the symbols mean. Winograd took on a procedure view of semantic, in which a symbol such as CLEARTOP can be expressed as a procedure:

```
1. Support(x, y), if not go to 4
2. Move y of x
3. Go to 1.
4. X is CLEARTOP
```

Despite being fresh and exciting, this view, however, turned out to be unimportant later on.

Since input of SHRDLU were English, it must first parse them into phrases. Winograd argued that in a realistic grammar, syntax and semantics are interrelated and must work in tandem. For example, the sentence *“put the blue pyramid on the block in the box”* is ambiguous because of whether *“on the block”* refers to the desired location where a user want to move the pyramid or its current location. In SHRDLU, the parser recognizes “the blue pyramid” and “the blue pyramid on the block” are possible phrases and uses its knowledge of the locations of the blocks to choose the correct interpretation.

3. What problems does it address?

SHRDLU was the first AI system to perform a realistic task. It takes on the problem of understanding language, and does it quite accurately. Certainly, the success was because of the limited block world, and we are still far from this in the real world.

Another success of SHRDLU is probably its ability to attain memory of its world, as in the planner’s example above. SHRDLU can also remember names. For example, one could say “a steeple is a small triangle on top of a tall rectangle"; and SHRDLU could later on answer understand what a steeple means in a sentence.

A side-effect of having memory is that SHRDLU can also answer questions such as what is possible and not possible in its world. The planner, after executing a command to put a block on top of a pyramid and discovering that this cannot be done somewhere in its history, can then deduce that this operation cannot be done without trying it. This is, although not a complicated deduction in SHRDLU, a demonstration of understanding.

4. Why does it matter?

SHRDLU was an inspiration and motivation behind many subsequent attempts to build AI systems. One example is the attempt to build SHRDLU-style dialogue for querying database by giving natural language commands, although this turned out to be difficult to handle real input because of the difficulty in natural language processing.

There was also suggestion that AI could be built from separate small world such as SHRDLU and then could combined. Although this view is not universally accepted, all useful systems today are operated in isolated micro worlds, such as chess, or a medical diagnostic system.

Regardless, SHRDLU was still one of the first systems to inspire AI research and imagination. Winograd research in which programming consideration can helps us to understand how a human reason and conversely knowledge of human cognitive can inform AI system development *"implies that AI researcher, linguist, and psychologist could achieve great things if they work together"*.

5. References

[1] http://en.wikipedia.org/wiki/SHRDLU

[2] http://www.semaphorecorp.com/misc/shrdlu.html

[3] Terry Winograd, "Procedures as a Representation for Data in a Computer Program for Understanding Natural Language", MIT AI Technical Report 235, February 1971