Combining Robocup Rescue and XABSL

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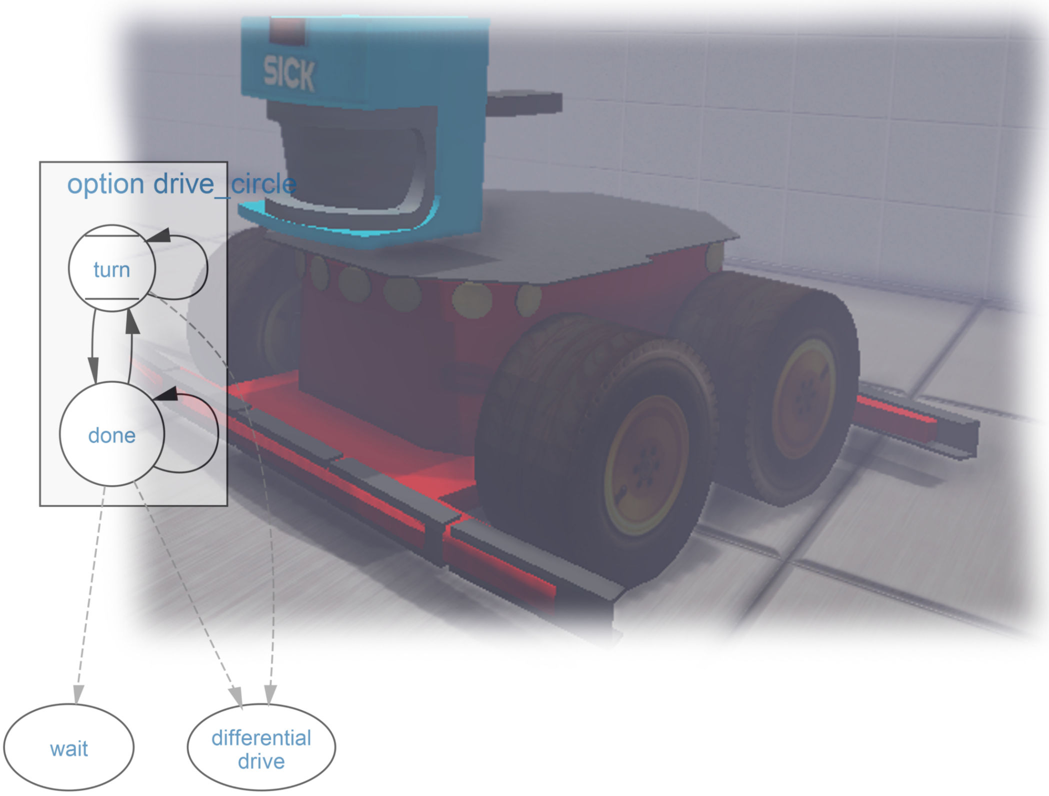

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Combining Robocup Rescue and XABSL

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Abstract

In this research, a product will be introduced, that combines the Extensible Agent Behavior Specification Language (XABSL) with any program, capable of having a socket connection. A use of this product is shown, by combining it to the rescue project on the University of Amsterdam, using *UsarCommander*, a program designed to control one or more robots, in a virtual rescue operation.

1 Introduction

The research will be focussing on combining the *Extensible Agent Behavior Specification Language* (XABSL) with any program capable of making a socket connection. In particular, the focus will lay on virtual rescue operations, otherwise known as the *RoboCup Rescue League*. Using a behavior specification language will make it possible to separate specification of behaviors from implementation.

Currently, the focus of research in the rescue missions is mainly on creating smart implementations of sensors. Much of the actual controlling of robots is done by hand, using programs that forward the camera images of the robots to a human operator controlling them. Some of these operators use simple behaviors to help them, like for example making the robot automatically traverse a path to a specified point. This kind of simple task can be called a behavior.

An improvement that can be made in these behavior controlled robots, is in the specification of which behavior should be selected in a certain situation and how the behavior is executed. This can be done by creating behavior-controlled robots, that can autonomously select the best behavior to activate on a certain moment, and using their sensors as input, can choose the right way to navigate.

This research will make use of XABSL, a behavior specification language, which makes it possible to separate the specification of a behavior, from the implementation.

Currently, not many behavior-controlled exploration algorithms exist. An exception is path finding on challenging terrain [4] . This research will result in a method to easily adjust and improve the behavior of any robot in any robot commanding program, especially focussing on UsarCommander, the program used by the UvA Rescue team[1].

There has however been research in Behavior Based Artificial Intelligence since 1986.

2 Behavior Based Artificial Intelligence

This was first researched by brooks [2], who laid the foundations of looking at intelligence in different layers. Brooks proposed that the following four elements were key requirements in a robot controlling system:

1. **Multiple goals:** A robot should be able to chase multiple goals at the same time, for example reaching a place in minimal time, while conserving power reserves. There should be an ability to prioritize goals, so that dangerous situations can be evaded while the main goals are still executed when the robot is able to. A simple example is being able to evade obstacles while reaching the place it wants to reach.

2. **Multiple sensors:** Most robots have more than one sensor, each having its own error measure. Some sensors have a bigger error in certain situations then others. For example while traversing inside a building, a robot should not be trusting its GPS sensor (Global Positioning Satelite), while being outside this would be a good option. A robot should be able to cope with these different errors, and use the right sensors at the right time with the right amount of trust.

3. **Robustness:** A robot's artificial intelligence should be robust. This means that when certain sensors fail, or unexpected deviations from it's normal environment occur (for example when a robot for inside-use comes outside a building, where there are less walls, but more smaller obstacles), the robot should still be able to act in a sensible way, in stead of just stop and stay still, or act randomly.

[1]Team description and more at: http://www.jointrescueforces.eu/wiki/tiki-index.php

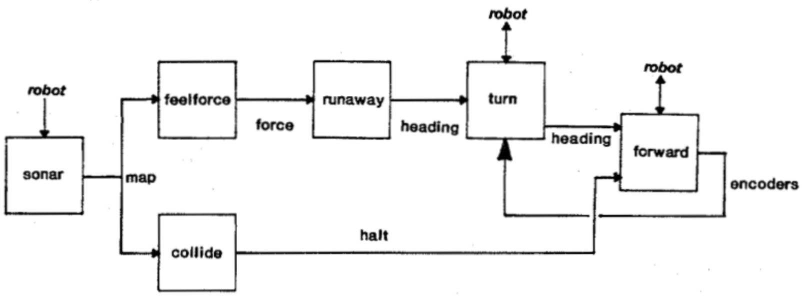

Figure 1: A level 0 control system, as proposed by Brooks

4. **Extensibility:** Brooks only speaks of being able to enlarge the processing power of the robot, when more sensors are loaded on the robot. I would like to add to this, that the intelligent system should have some kind of modularity in its software, making extending the system to work with a new kind of sensor, or even a totally different robot or environment (for example virtual vs the real world) easy, without having to rewrite big parts of code, or search through the program to find where a sensor should be added and where the activation of the sensor occurs, etc.

Brooks explains that typically, robot intelligences slice problems up in the following order: Sense, map sensor data in a world representation, plan, execute task and at last: control motors to do so. He then offers a new implementation of problem-decomposing, in the following order, and calls these 'Levels of competence'

0. "Avoid contact with objects (whether the objects move or are stationary)."
1. "Wander aimlessly around without hitting things."
2. "'Explore' the world by seeing places in the distance that look reachable and heading for them."
3. "Build a map of the environment and plan routes from one place to another."
4. "Notice changes in the 'static' environment."
5. "Reason about the world in terms of identifiable objects and perform tasks related to certain objects."
6. "Formulate and execute plans that involve changing the state of the world in some desirable way."
7. "Reason about the behavior of objects in the world and modify plans accordingly."

Each level of competence adds complexity to the entire system, thereby creating a layered implementation of behavior in an (in that time) untraditional way. Brooks proposes that each of these layers can be implemented in a finite state automaton, resulting in figure 2 as a representation for the zeroth level, and, by augmenting this with an FSA for level one and two, in figure 2.

In the level 0 representation, the robot will 'run away' when it is standing still and a moving object closes in. Alternatively, it will halt when a probable collision is detected. This is enough for simple obstacle avoidance.

This representation is augmented by inserting the avoidance and wander states above it parallel to the runaway state, in figure 2, This results in level 1 behavior: a robot capable of wandering around aimlessly, without hitting any objects. The direction outputted by the level 0 FSA is, when possible, overridden by the direction of the level 1 output.

As can be seen, this method a very large FSA, when we add the second level of control. This has the advantage of being capable of more complex behavior, in this case exploring an area, thus no more simply wandering around, but reaching places it has not yet explored. A disadvantage of this method, however, is that these big FSA's are quite complex to understand Adding more and more complexity to the system results in bigger and bigger images, resulting in more representation complexity and, in the worst case, in a system that only the creator can understand fully, but cannot anymore be

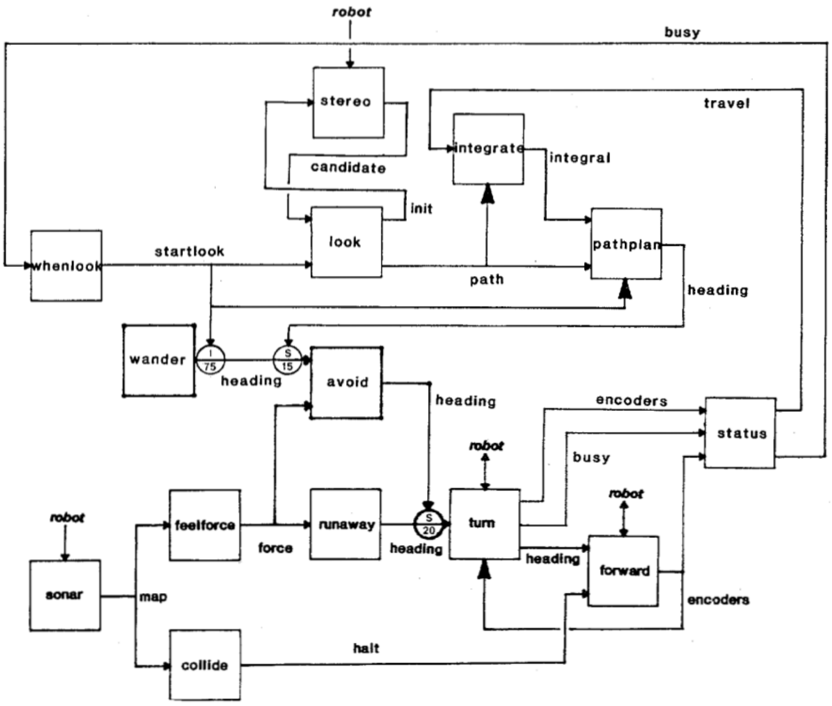

Figure 2: A level 2 control system, as proposed by Brooks

represented in a clear way. Of course it needs to be considered that this system was created in 1986, when computers were many times slower and capabilities were limited. Brooks managed to get the level 2 version working on a real robot in the time, by distributing the system over many cores.

This is the main advantage Brooks proposes, of this kind of implementation: The processes needed for the in- and output of the states, can be done with the least possible interaction between processes, making Brooks able to distribute the implementation over different processors and thereby able to run this, for that time, complex program.

Nowadays, this implementation is a bit outdated, mainly because of the complex structure of the representation. The behavior based approach, however, has been used in several solutions to controlling robots. These solutions will be discussed in the following section.

3 BBAI Implementations and Alternatives

This section will cover most of the BBAI implementations that can be chosen from when deciding to create an application that should be capable of specifying a Behavior Based artificial intelligence.

3.1 XABSL

One of the implementations of behavior based software is *XABSL*: a programming language, created to easily describe behaviors for autonomous agents based on hierarchical finite state machines [3]. It is the software that has been used by the German robotic soccer team to specify their robots' behaviors. The team won in 2008, and the years after that.

The language is used to specify a finite state automaton hierarchy. This means that the user defines several finite state automata, which can activate each other. Each state makes decisions on certain variables, and as an output activate another state or another FSA. The hierarchies are built up from the following components:

A XABSL-specification is built up from the following components:

- *Agents:* A rooted acyclic graph, containing all the behaviors for one agent. Several of these agents can be created, all having their own graph and thus their own behavior.

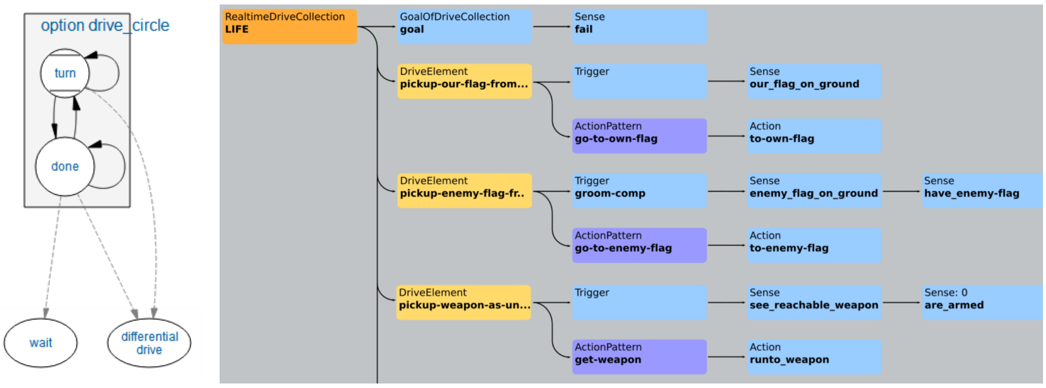

Figure 3: Left: An example of a figure generated by the XABSL compiler, from XABSL code. Right: a POSH hierarchy

- *Options:* Complex agent behavior. Each option is on itself a finite state machine, containing several states. When creating an agent, the start option can be specified, which makes the user able to create different agents from one Option hierarchy. Options can also have parameters, enabling an option to have different outputs for different agents. Figure 3.1 contains an example of a simple option, that makes the agent turn 360 degrees and then stop and wait for a certain amount of time.

- *States:* Options are bounded to each other by states, each state has a decision tree, and an action. The decision tree decides whether to stay at this state, or to go to another state. These decisions are based on variables that can either be internal, or inputs.

  When a decision tree decides to stay at its current state, an action is performed. Actions can be activation of a basic behavior, or of another option. Several actions per state are permitted.

- *Basic behavior:* At every leaf of an option (so, every state with no other states to reference to) a basic behavior is activated. This is a small piece of native code (C++ or Java), that influences the actions of the agent in its world.

This is an improvement over Brooks' BBAI, because the FSA's are now no longer directly connected to each other through state connections, but are connected via the actions of certain states, in that way improving the comprehensibility of the representation, thereby also improving the modularity of the system, because modules can be better recognized and then expanded.

By using basic behaviors, that can be written in C++ or Java, XABSL also enables distribution of the system: Each basic behavior can run its own module. This way basic behavior can be a module that simply makes a robot move, but also a module that finds a ball in a soccer field, using libraries like OpenCV. This makes a XABSL application capable of the same things as any native C++ or Java application, which is almost everything one or more computers can do.

Section **??** will explain more clearly the advantages of XABSL, and the possibilities of agents, options, states and basic behaviors.

3.2 POSH

POSH [1] is a very similar alternative implementation of a Behavior Specification Language. Posh is defined as a *Behavior Oriented Design*, which is a combination of *Object Oriented Design* (OOD, used by object oriented programming languages like Java and C++) and *Behavior Based Artificial Intelligence* (BBAI).

From OOD the language takes the object hierarchy that it is known for. In object oriented languages a person is capable of creating an object based on another object. These can be *Abstract classes*, or *Interface classes*. When using an abstract class to define an object, this means the class can be extended by another object: The new object automatically has all the properties its *Base class* (the original, abstract, class) has, but can override some of them, or add new ones. An interface class can define what its subclass should have, for example when an interface class specifies a method that searches for a doorway, using laser sensors, its subclass should implement this method. The interface class itself does not have any actual implementations. BOD objects are literally built in an object oriented language, thereby having all its advantages

The BBAI-part of it is the decomposition of intelligence as subtasks called *acts*. Examples of acts are knowing your position and planning a route. There is no implementation of prioritizing certain acts above others, other than that they come earlier in the POSH diagram.

Behaviors in BOD are thus specified as a *Behavior object*, written in an Object Oriented language. They are split up in actuators and senses. The actuators are used to act on the world, for example move in a certain direction, or pick something up, whereas the senses are used to inform the planner the current context. Context can be any piece of information about the world, or the agents internal state. The whereabouts of an object, or the data from a laser scanner can be context, but the agents current battery level is also context.. All the specified behaviors together form the *Behavior Library*, which can be used by the action planning system to select the right behavior on the right time.

Furthermore POSH uses three aggregates: simple sequences, competences and drive collections.

1. **Simple sequences:** The sequence is simply a sequence in which order a diagram should be traversed

2. **Competences:** A competence is a prioritised set of condition-action pairs. These condition-action pairs are based on the current context (described above). Because of the hierarchical structure of the system, only small pieces of context have to be processed at a time. When a certain part of competence is reached, competences have been passed higher up in the hierarchy, meaning that this information needs no more checking. In this part there is assumed that in the time it took to traverse the tree, the world has not changed significantly.

3. **Drive Collections:** The drive collection is a special competence, that is executed before each program cycle. The collection contains all vital condition-action pairs to be able to survive. For example when an enemy is close (given that the environment has enemies that can seriously harm the agent), the agent should hide from the enemy, or take other actions not to get harmed. The drive collection can also contain routines that have to be executed every once in a while, like checking the environment for safety

This is actually quite similar to XABSL, because selects actions based on decisions based on its findings. The actions are always executed by an external program. There are some important differences though:

- POSH is designed to be used by non-programmers. This means the interface is easy, colorful and simple, whereas XABSL prioritizes complex capabilities, ignoring the fact that non-programmers then couldn't use it. This improves the adaptability of XABSL far above the capabilities of POSH, resulting in ability to create more complex behaviors.

- Where XABSL has a close coupling with the perception stream of the robot, POSH has no variable management, enabling the system to be a lot easier to use, but also maximizing the complexity of the specified behaviors to a lower maximum than XABSL offers.

3.2.1 The next thing

I don't know yet, let's see tomorrow

3.3 XABSL specification

XABSL makes use of four components: Agents, Options, states and Basic behavior. The following subsections will explain what these are, and how they can be used.

3.4 Agents

An XABSL agent is a rooted acyclic graph, containing all the behaviors for one agent. In this research, one agent will equal one robot.

3.4.1 Motivation to use it

Using FSM's for behavior is an easily comprehensible method to specify behavior. The advantages of XABSL are that tools are delivered to make a hierarchy documentation for your website (or anything else). For example, the FSM in figure 3.1 is automatically generated from XABSL code.

Using this representation, tweaking the behavior should become an easier task resulting in better results for autonomous exploration.

This section will be expanded with the following:

4 RoboCup Rescue

4.1 Description

The project used in cooperation with the application, is UsarCommander. UsarCommander[2], originally developed by Bayu Slamet, and extended by Arnoud Visser and many others. This program takes care of connecting to USARSim (the simulator used in the Robocup) and makes the user able to easily get sensor data from the robots in it. It is also possible to control the robots with several types of behavior, like corridor-following, obstacle-avoidance, or tele-operation. The last of which enables the operator to manually control the robots by hand, using an interactive human interface.

Over time, the system has been expanded with many subprojects, for example one implementing a SLAM (Simultaneous Localisation And Mapping) algorithm, to make an accurate map from the sensor data of several robots [5]. All the information used and produced by these subprojects can be accessed by other subprojects, resulting in an ideal environment for creating new robot-controlling applications.

4.2 Motivation to use it

The main reason to use this program, instead of any other, to interface my software with USARSim is that it has so many features. The presence of many subprojects in the code, makes it possible to make a very efficient autonomous exploration algorithm interfacing with the subprojects at hand. Without using UsarCommander all the needed software should be taken from somewhere else, or implemented solely for this purpose.

Other software for this purpose is available too.

but since this is a bachelor thesis on the University of Amsterdam, and this is the software used by it in the RoboCup, this is the logical choice.

5 Approach

5.1 Interfacing both programs

Since the UsarCommander is written in Visual Basic, and the basic behaviors of XABSL are written in C++, a bridge should be made. This is done by creating a Dynamic Link Library (DLL). This DLL contains the needed functions of the C++ program, making them accessible for Visual Basic. The bridge works both ways, so Visual Basic can offer output symbols to the XABSL Engine, while the engine can offer input symbols to the agent.

5.2 Creating a succesful hierarchy

This section will tell about the FSM hierarchy I will make for autonomous exploration

[2] Available at http://www.jointrescueforces.eu/wiki/tiki-index.php

6 Results

This section will contain results, hopefully in the form of explored maps, numbers of victims found, etc.

7 Conclusion

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