A Semi-Autonomous Interactive Robot

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Introduction

Over the last ten months, we have been developing a robot capable of intelligent human-robot interaction. By employing relevant techniques such as speech recognition, natural language processing, and logic-based action, it was possible to design a robotic system capable of interacting with human beings.

Software Design

Logic and Natural Language Processing

The Logic and Natural Language Processing (NLP) aspects of this robot were implemented in Prolog, a prominent logic programming language. Using Prolog, it was possible to design software that made intelligent decisions based on information provided to it regarding the state of its environment and itself.

The logic software was divided into a few categories: Movement, Conversation, and General Logic. Each of these was implemented in a separate logic program. This way, they could be accessed concurrently. Furthermore, the separation allowed one or more to be ignored as necessary in order to maintain proper operation.

These aspects of the software structure were created as Dynamic Link Libraries (DLLs) that could be called by interface software. By passing strings to the functions exported by the DLLs, these functions could be implemented in any higher level programming language chosen to act as a real-world interface.

Speech Recognition and Real-World Interface

As the robot was designed for human interaction, it was necessary to design interface software that seamlessly connected the real-world to the logic NLP software controlling the actions of the robot. Doing so would allow TARO to exist in as a utility-based agent in a dynamic environment: the real world. [Russel et al. 1995]. To do so, it was necessary to design and implement software capable of speech recognition, simulated facial expressions, and text-to-speech enabled audible responses based on user input and environmental factors. The interface software necessary for the robot was implemented in Visual Basic and uses the Microsoft Speech Software Development Kit (SDK) for efficient and accurate word recognition.

Speech Recognition. Perhaps the most critical aspect of the software was the implementation of well designed speech recognition software. Using the Microsoft Speech SDK, it was possible to realize both voice based movement control and the capability for human-robot conversational interaction.

Rather than employing simple dictation algorithms for speech recognition, which can lead to poor recognition results, we employed a modified command-based system. By defining structures that limited the number of possible word combinations, the recognition rate was increased dramatically. Furthermore, filters were setup that disallowed some possible word choices based on the status of the conversation at hand, the state of the robot, or the state of the environment. With this in place, it was possible to get high accuracy rates in terms of understanding and response.

Real-World Interface. Also coded, in Visual Basic, it was the purpose of the interface software to create an agent with which a human being could interact. First, a graphical representation of the robot was created in the form of a face. This face both mirrors the "emotional" state of the robot as well as follows the speech patterns from the text-to-speech software in order to create the illusion of a speaking entity.

The second piece of the interface software involved audible speech. By implementing text-to-speech algorithms triggered by strings passed from the logic DLLs, it was possible to give the robot a voice with which it could interact with other agents in its environment.
Finally, software was implemented to semi-autonomously control the motion of the robot's mobile platform. In

addition, code was written to control the two robotic arms connected to the body of the robot. Integrating this software with the speech and graphical elements creates a dynamic and robust interface to the real-world.

Physical Systems

Mobile Platform

The purpose of the mobile platform is to supply the robot with a stable foundation and the capability of mobility. The platform is composed of a bottom frame, a lower platform, an upper platform, two motors, and wheels.

The frame is constructed of 6063 series boxed frame aluminum and is a rectangular shaped structure. It measures 20 inches by 36 inches and is welded together at the corners. On top of this frame, a Plexiglas platform is bolted down that serves as the foundation for the robot's battery, computer, and motor controllers. Four 12 inch, 2 inch diameter PVC pipes were then bolted to the lower platform via flanges, and are connected to an upper 15 inch by 26 inch Plexiglas platform that serves as the base for the upper body of the robot.

The front wheels of the robot are 10 inch rubber tires, which are directly driven by the motors in the mobile platform. The back wheels are 7 1/2 inch caster wheels. The two wheels' speeds will be varied and controlled by the motor controllers, and this difference of speed, along with the free flowing nature of a swiveled caster wheel, will allow the team to control the motion of the robot's mobile platform.

Finally, the two motors chosen for the system are 12VDC Dayton Brushed Gear motors each supplying a 1/6th of horsepower to the robot. They are directly coupled to the two front tires via machined couplings that fit tightly onto the motors' shafts and utilize set screws. Furthermore, these couplings are welded to the actual wheel wells of the front tires, thus completing the motor-wheel integration.

Upper-Body

The upper-body of the robot contains both the visual (monitor) and physical (robotic arms) interactive devices. The support structure for the upper-body was constructed out of PVC tubing, which was chosen for reasons of cost effectiveness and ease of implementation. PVC tubing also allowed wires to be run through the robot without being seen and exposed, making it aesthetically pleasing Also, since there are many PVC standard connectors and sizes, all the necessary flanges and connections within the upper body were easy to make.

The goal of the upper body was to appear as humanoid as possible in shape and function. Noting that the main goal of this competition is to promote human-robot interaction, some research was done on how humans act with each other. In the commonly accepted Mehrabian model, it was noted that only about 7% of the effectiveness of communication is in actual words being spoken. The other 93% of meaning inferred by communication is attributed to body language, facial expressions and tone. [Chapman 2004] Here the upper body plans to capitalize on the use of body language through the use of having robotic arms and facial expressions to allow the robot to express itself more clearly.

The main function of the upper body is the support of the monitor and the robotic arms. These two actuators allow for human-robot interaction by simulating two human actions: waving and shaking hands. The left hand was designed to pivot about its elbow joint, and when controlled by the microcontroller give the illusion of waving. The right hand also pivots about its elbow, but in a direction that raises the lower arm to a position where handshaking is possible. On contact with the hand attached to the arm, a series of signals are sent to the motor in the arm causing it to change direction at a rate that closely resembles handshaking.

Conclusions

The robot we have designed is an excellent step in the direction of interactive robot development. The merging of Prolog and Visual Basic provide an excellent foundation for future development. The team will continue to work to make TARO capable of increasingly intelligent and interesting human interaction.

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