Simulating Military Radio Communications Using Speech Recognition and Chat-Bot Technology

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In the real world commanders and soldiers use their radio networks to communicate with each other, issue orders, and deliver reports. However, most modern training simulations provide no mechanism for a commander to speak to the simulation and receive a response in the same manner. We believe that a combination of commercial voice recognition, voice generation, and AI chat-bot tools can be used to create a more realistic interface for military personnel interacting with a simulation.

This paper describes the Voice-Simulation Interaction Module (V-SIM) research project in which we have created a spoken voice interface that uses artificial intelligence to interact with a military simulation. This paper will focus on the modification of the AI to interact using standard military radio messages, techniques for setting up a network of these entities, methods for connecting V-SIM to the SAFs and some of the research and prototypes that are currently being tested.
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INTRODUCTION

Most modern warfighter simulations require users to interact with the simulation through a role player who acts as a member of the military training audience but is actually a supplement to the computer simulation. This human’s job is to provide the voice of the simulation and to serve as a translator from tactical orders into computer executable commands. In large staff training exercises, these role players are being partially replaced by the use of direct simulation-to-C4I interfaces. However, in lower-level operational training scenarios, the training audience must interact via spoken voice using radio equipment. Chat-Bot technologies have the potential to replace role players who must speak to the training audience. Our research has been in identifying the best chat-bots for this application and creating databases that can drive these chat-bots for military training. Applying these technologies also requires the integration of a number of different software applications, which is the secondary focus of our research.

Although Chat-Bot technology still has a long way to go in the field of parsing and responding to conversational natural language, the technology has developed enough to handle the structured forms of military radio communications. By modifying the AI of the Chat-Bot to handle these communications the Chat-Bot can interact with the user via formatted radio messages. The Chat-Bot can then be attached to the AI of the SAF and act as its command interface. The command staff can then send radio messages to the SAF, just as they would with real forces, and the SAF would act accordingly. Currently these radio messages must be text based, however given the available technology and advances in voice recognition software these interactions may soon be performed via voice or radio transmissions. A Battalion could set up their Tactical Operations Center and command real and virtual units over the same radio network operating as they would in wartime.

This paper will focus on the modification of the AI to interact using standard military radio messages, techniques for setting up a network of these entities, methods for connecting Chat-Bot AIs to the SAFs and some of the research being done with our prototype, the Voice - Simulation Interaction Module (V-SIM).

HISTORY OF CHAT-BOT TECHNOLOGY

Chat-Bot like technology has been around for nearly 20 years, but has only recently been gaining wide spread use. The first Chat-Bot, so to speak, was the Eliza program [Wieizenbaum, 1966]. This was a psychologist Chat-Bot created by Joseph Wieizenbaum, a professor at MIT. A few years ago, Dr. Richard Wallace wrote A.L.I.C.E., the Artificial Linguistic Internet Computer Entity, a new Chat-Bot program [Wallace, 2000]. It won the Loebner Award, which is the first formal instantiation of a Turing Test. The test is named after Alan Turing the accomplished British mathematician. In 1950, in the article Computing Machinery and Intelligence for the philosophical journal Mind, Alan Turing asked the question "Can a Machine Think?" He answered in the affirmative, but a central question was: "If a computer could think, how could we tell?" Turing's suggestion was, that if the responses from the computer were indistinguishable from that of a human, the computer could be said to be thinking. After winning the Loebner Award, A.L.I.C.E. was later updated by Dr. Wallace, Jon Baer, and others and programmed in Java. They later set up the Alice AI Foundation to promote the programming of Alicebots and help direct the new Artificial Intelligence Mark-up Language (AIML).
Components of the Chat-Bot

The Chat-Bot software is composed of three main components, a Responder, Classifier, and Graphmaster, as shown in figure 1. The Responder, which is the interface between the user and the core routines. It handles the input and output, transfers user data to the Classifier, and delivers the bot’s response to the user. The Classifier normalizes and filters the input. It applies substitutions and splits the user input into logical components. The normalized strings are then transferred to the Graphmaster. The Classifier also processes the output from the Graphmaster, handles various AIML instructions, and delivers the bot’s response to the Responder. The Graphmaster organizes the storage of the brain contents. The content is stored as a graph. The Graphmaster handles the pattern matching process, which involve an advanced search-tree algorithm (see figure 1).

Artificial Intelligence Mark-up Language

AIML enables people to represent knowledge into Chat-Bots based on the A.L.I.C.E software technology. The Alicebot software community developed AIML during 1995-2000. It was originally adapted from a non-XML grammar also called AIML, and formed the basis for the first Alicebot, A.L.I.C.E.

AIML describes a class of data objects called AIML objects and partially describes the behavior of computer programs that process them. AIML objects are made up of units called topics and categories, which contain either parsed or unparsed data.Parsed data is made up of characters, some of which form character data, and some of which form AIML elements. AIML elements encapsulate the stimulus-response knowledge contained in the document. Character data within these elements is sometimes parsed by an AIML interpreter, and sometimes left unparsed for later processing by a Responder. The AIML also has the ability to use JavaScript within the categories and it can be used to call executables.

Figure 1 Chat-Bot Components
Figure 2 is a graphical depiction of the AIML parsing tree. The large nodes with numerous branches represent patterns associated with common interrogatives like WHAT, WHO, WHEN, and WHERE.

**Chat-Bot Interfaces**

Most Chat-Bots currently in use are text based. The user and the Chat-Bot communicate via text-messaging or some other form of keyboard interface. Technology for speech recognition and text to speech generation is improving rapidly and some Chat-Bot interfaces are beginning to use these. It will soon be common to deal with computers and even Chat-Bots through speech recognition. There are quite a few programs available today, such as Naturally Speaking or ViaVoice, that use this type of technology for hands free use of operating systems and computer applications. This technology can also be experienced in many automated phone response systems. By using this speech recognition and text to speech technology the Chat-Bots can be adapted to interface over phone lines, via computer terminals, and hopefully someday over standard radio communications devices.

**V-SIM the Chat-Bot prototype**

The Voice-Simulation Interaction Module (V-SIM) is a prototype Chat-Bot interface designed to use Speech Recognition and Text to Speech COTS software. Currently V-SIM is using the Microsoft Speech SDK for speech recognition and AT&T Natural Voice for Text to Speech generation. V-SIM is designed to be modular allowing the addition or removal of the base components. The modular design also allows for modification and adaptation to a variety of simulations including DIS and HLA networks. One of the main goals of V-SIM is to utilize low cost COTS and GOTS products to create a usable interface at minimum expense.

**USER INTERACTION WITH SEMI AUTOMATED FORCES**

In the majority of modern warfighter simulations interaction with the Semi Automated Forces (SAF) is typically controlled by point and click techniques. Drop down menus and other graphic interfaces controls are used to set SAF dispositions and its actions. These types of controls are effective for the purpose they were designed for but they do not provide a realistic interface. In today’s military training environment integrating simulations with real world exercises is becoming increasingly
important. More and more simulations focus on interacting with real units out in the field, but how can a commander experience the realism of the training if they are directing half of their units by pointing and clicking on a computer screen and the other half by standard radio communications?

To create a truly realistic “Train as you Fight” environment the simulation should be able to interact with the battlefield commanders in the same manner as the real players. It is this problem of interaction that this paper focuses on and will attempt to address using the Chat-Bot technology, and the V-SIM prototype.

SAF Communications

There are a variety of methods in which SAFs communicate. The automated forces may be directed by the user using point and clicks, by drop down menus on a graphic user interface, or the SAF may be directed by the simulation, directly based on orders or choices given by the users. These directions to the SAFs can take any number of forms from interactions to directly changing parameters within these automated forces.

These techniques are designed for efficiency in the computer system, and to accomplish the simulations overall mission. Often realism of interaction is not taken in to account or even considered by these simulations. This is not a shortcoming in the simulation it is simply how it was built given its design parameters.

Real World Communications

When a battlefield commander directs his troops it is typically done through radio message traffic. His communications staff operates the radios that keep him in touch with his troops as well as superior and subordinate commands. Everything from command and control through supply and support are handled via these radio messages.

The format for these messages is very structured and static. Specific messages have specific formats with each line having a specific meaning. Deviation from these patterns is rare and there is little change in standard radio procedures. These radio messages are also made up of generic radio communications such as radio checks, call-ups, sign-offs and authentication. It can be viewed as a small subset of natural language with some changes made to the grammatical rules and message structure.

Descriptions and specification for these messages and procedures can easily be found in military radio communications manuals such as FM 11-32 Combat Net Radio Operations, Signal Operation Instructions (SOI) and even the United States Message Text Format (USMTF) message format manuals.

This is how the battlefield commander communicates with his units, not through pointing and clicking on icons on a computer screen, or drop down menus, and while the day may come when that is how military units are directed, that is not the case today. In an ideal training environment the commander would operate just as he would in wartime and the crux of the problem is how to integrate this realism into modern simulations.

V-SIM AND THE SEMI AUTOMATED FORCES ARTIFICIAL INTELLIGENCE

How do you solve the problem of realistic SAF interaction? One possible solution is the use of Chat-Bot technology, as incorporated into V-SIM. It uses the Chat-Bot’s native artificial intelligence (AI) to interact with the user. By tailoring the Chat-Bot’s AI to handle standard military radio message formats and procedures it can be adapted as an interface for the SAFs.
Modifying the Chat-Bot AI to Parse Military Communications

Creating an artificial intelligence program to deal with natural language is no small undertaking. The complexities of natural language are vast and trying to determine and deal with all possible permutations is a daunting task. Many decades of research have been spent on this problem. Fortunately, the strict patterns and rules of military communications removes much of the vexing complexities inherent in more general natural language understanding problems. Military communications are very structured in their nature and have certain protocols, which must be followed. There are certainly variations allowed but nothing as substantial as natural spoken language. Modifying the Chat-Bot AIML to deal with these types of communications, though a non-trivial exercise, is feasible and manageable.

The first step is in setting up the AIML to deal with callsigns and programming in the rules of military communications. Message structure must be set up and ways of determining content or topic must be written in. Formal radio messages should always begin with the sender and receiver’s callsigns, and lines of message should always end with either “over”, “break”, or “out”. The AIML is set up to check these and determine if the proper sender and receiver were used in the message, and that messages are terminated properly. This is used for error checking, as a means for determining when the message is complete and parsing should begin, and will be seen as a device later used for determining which SAFs are being directed by the User.

All communications start out as generic radio messages. This means that the usual call-ups, radio checks and authentication are all covered under one section of the AI. When a message is initiated it starts with a call-up. This is the sender calling the receiver. The receiver in turn acknowledges this. Then the authentication takes place. Once this is completed the sender moves into the message they wished to send. When a specific message is sent the AI topic is set to that message and all messages are parsed under that message specific topic. This allows for putting the proper information in the correct context. V-SIM can then store the information in a database for later use and/or use by the SAF. Once this message is complete the AI resets to the generic radio message topic and is ready to deal with any new type of message. Once all messages have been sent and received the AI then resets to the generic communications and sign-off can

User: “B20 this is C3E, Adjust Fire, over.”

Chat-Bot: “C3E this is B20, I copy Adjust Fire, over.”

Chat-bot response generated by Graphmaster. Topic set to Call for fire.

User: “B20 this is C3E, Grid AB123456, over.”

Chat-Bot: “C3E this is B20, I copy Grid AB123456, over.”

Chat-bot response generated by Graphmaster.

User: “B20 this is C3E, Infantry Platoon in the open, ICM in effect, over.”

Chat-Bot: “C3E this is B20, Infantry Platoon in the open, ICM in effect.
Authenticate Alpha One Romeo, over.”

Chat-bot response generated by Graphmaster with authentication added.

User: “B20 this is C3E, I Authenticate Delta Five Romeo, out.”

Figure 1 Chat-Bot Message Parsing Example
take place between the sender and receiver. The Chat-Bot is then ready to begin again.

Given the correct type of prompts or stimulus from a driver program, such as a SAF, the AI can be used to send information as well. V-SIM can read the data from a database and feed it into the AI, which inserts it into a message. The message is then sent out to the user in military radio message formats using standard procedures. An example of this would be a SAF tank that is hit by enemy fire. The Chat-Bot would monitor the status of the tank and when its health was lowered due to the hit it would initiate a call to its higher headquarters stating that it had come under attack.

![Diagram of V-SIM to SAF Interface Flow Through]

**Figure 2 V-SIM to SAF Interface Flow Through**

**Connecting V-SIM to the SAF AI**

V-SIM is fairly flexible in how it deals with SAFs. It can be configured to pass data directly to a given SAF or it can store data in a database to be accessed by multiple SAFs. These configurations allow V-SIM to be adapted to most modern simulations. In some cases a driver program or interface may need to be written for it to deal with specific types of SAFs, but the data in general and the interfaces with the user should remain constant.

The V-SIM AI can be configured to directly call functions on a SAF sending the commands directly to the unit. This works best on a one to one scale with V-SIM representing only one SAF. As it can act as multiple actors the database storage technique can be the most effective for handling multiple SAFs. In this technique the data for each SAF is stored in a specific area of the database. When the SAF needs to pass data back and forth to the User it reads and writes data from its specific area. This allows V-SIM to handle traffic for multiple entities without using up large amounts of system memory.

In cases where the SAF entities cannot deal with the database, then a driver or interface program would need to be adapted. Other techniques for connecting to the SAF could certainly be developed and are only limited by imagination and need. The interface could be tailored to the different simulation networks.

**Network Simulation Techniques**

Within the context of this type of training, there are multiple communication networks that need to be represented. These networks represent different areas of interest within the military communication
infrastructure. Examples of this include a Command Network and a Supply and Support Network. These networks often have sub-networks based upon echelon. In addition to being logical, these networks are often physical as they quite often use separate, reserved radio frequencies for their communication traffic.

The use of these networks, like the format of the radio messages themselves, is well defined and quite independent of the other communication networks. This well-defined and independent nature lends itself to the use of separate instances of V-SIM per predefined radio frequency each representing the entities likely to be encountered on that corresponding communication network. While these networks are quite independent, knowledge of dynamic “ground truth” within the simulated world would need to be represented to the appropriate extent. V-SIM would access this type of situational information through a common database or through their interface to knowledge gained and stored by the SAF entities they represent.

In the case of either a part-task radio operator trainer or an interface to SAF, the switching of V-SIM instances representing the different communication networks would be achieved through the user interface. This user interface would require the “dialing up” of the proper frequencies through standard menus or graphical representations of actual equipment, such as the SINCGARS interface developed using GL Studio. V-SIM would then respond in a doctrinally correct way to messages on the networks it represents. Messages sent to inappropriate networks would easily be caught by that network’s instance due to the invalid call signs that would be used.

OTHER APPLICATIONS

The adaptation of V-SIM to other current and future applications has a great deal of potential. Specifically the use of standardized radio message formats has many applications in the modeling and simulation fields.

V-SIM as a Radio Operator Trainer

One application of the V-SIM technology that could easily be constructed using the current technology is a computer based radio operator part-task trainer. A prototype of this has already been created for the SINCGARS radio. V-SIM can walk the radio operator through an interactive tutorial teaching the soldier how to operate the radio as well as allowing them to practice sending and receiving message traffic just as they would on real radio systems. Call-ups, authentication, messages and sign-offs could all be practiced without the need for setting up actual operational radio systems or performing complicated radio exercises. This trainer could be part of a distance learning curriculum, or distributable to units and schoolhouses allowing soldiers to stay proficient in radio communications procedures with a minimum of support required.

COMINT Enhancements in Simulations

An underdeveloped area in modern simulations is communications intelligence (COMINT). Unless the simulation is specifically designed to provide this type of data to the users it is typically non-existent. As explained in the earlier section SAF entities typically communicate and interact without any type of generated signal or message. They are simply not designed for this purpose.

Why is this information important? Intelligence systems are becoming increasingly important on today’s battlefields and in planning for future military operations yet it is one of the most difficult areas to train. By using the developed V-SIM technology and attaching it to the AI of the SAF these missing messages can be generated and inserted into the simulation for the intelligence system operator to collect on.

The SAF operates as normal with the addition of the V-SIM connection. V-SIM monitors the SAF and when triggered by the SAF’s actions a doctrinally correct message is generated and put out on the network. This can also be used between SAFs when they are interacting. These generated messages can then be collected by the intelligence system operator and reported as they would any collected intelligence. V-SIM would be more dynamic and varied than the majority of the canned recordings currently in use. This message traffic generation would significantly increase the quality of the training for the operator and give them more information to report on. The added Intelligence value would also enhance the command staff’s view of the battlespace, thus increasing the quality of the training.

Inter-Simulation SAF Communications

Another possible future application of this technology is in inter-simulation communications. One of the problems faced today is connecting various types of existing simulations together to create a more comprehensive trainer. By using these standardized radio messages SAFs could communicate from one
simulation to another without the necessity of adapting their network structure to multiple simulations and systems. It is even feasible that these simulations could interact over radio networks just as the real forces operating in the simulation. A radio operator could feasibly talk to SAF entities in multiple simulations over their radio network just as they would the real players. Similar research is being conducted on this type of inter-simulation communications. One major effort in this field is the Battle Management Language [Hieb, Tolk, Pullen, and Sudnikovich 2004].

CHALLENGES

While the current capabilities of Chat-Bots and the AIML are extensive and very adaptable to modern simulations there are still several challenges to be faced. V-SIM tries to deal with these problems by implementing software work-arounds and adapting the technology to deal with this limited problem space of military communications.

Limitations of the AIML

One of the biggest problems is in the limitation of the Artificial Intelligence Mark-up Language capabilities. The language is designed for a simple query and response kind of interaction with the user. To be more effective in simulations the language needs to be given more interactive capabilities. It needs to be able to initiate communications and be more pro-active in communicating with users. This can be accomplished by extensive work in generating AIML files, but will need some help by adapting the driver, or chat programs to be smarter and more simulation driven.

Speech Recognition and Text to Speech Generation

Another major problem for future use is in the areas of speech recognition and text to speech generation. While this can be done in a quite environment at a computer terminal the technology is not currently at a level that would allow use over a radio communications network. Any static in a received message would be difficult for the speech recognition software to interpret and would result in numerous incorrect responses. V-SIM tries to accommodate for some of this by using keywords and pre-filtering of speech to determine the gist of the message and discarding ancillary words or sounds. There is current research going on in this field, but it has been unable to accomplish this with the SINCGARS radio due to sound quality issues [Daniels and Bell, 2001]. The difficulty in the text to speech generation is in the realism of communications. For the ultimate level of realism the user wouldn’t be able to tell if they were talking to a real person or to a computer. Unfortunately the current technology is machine sounding. The speech doesn’t flow smoothly and voice is obviously machine generated. Hopefully future developments in the fields of speech recognition and text to speech generation will solve these problems.

SUMMARY

The field of Chat-Bot technology is rapidly burgeoning. By adapting this technology to military radio communications and developing interfaces to modern computer simulations the realism of the training environment for battlefield commanders and their staff can be greatly increased, and the line between real units and SAF units in a simulation can be made a little fuzzier. The potential for a wide variety of uses exists in these Chat-Bots. The technology currently exists for application development now, and the rapid expansion of this field ensures the increase in capability and greater realism in the future. With the development of prototypes, such as V-SIM, hopefully interest will grow within the modeling and simulation communities.

REFERENCES


V-SIM DEVELOPERS AND AUTHORS

Donald J. Stoner is a Software Engineer for the Titan Corporation. He has developed tools for visualizing simulation events, for networking multiple simulations, and modeling intelligence sensors in simulations. He is a former member of Army Military Intelligence and Special Forces with experience in signals interception, reconnaissance and surveillance.

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