Lab Notes

NEWS FROM AROUND LINCOLN LABORATORY

SIMULATIONS

A Serious Game for Intelligence, Surveillance, and Reconnaissance

A simulation experiment provides hands-on experience analyzing sensor data to discover mobile targets

For the past two years, people at Lincoln Laboratory's Introduction to Intelligence, Surveillance, and Reconnaissance (ISR) Systems and Technology course attended the expected lectures on different sensors and techniques used to provide military operations with ISR data. However, each year's group of about 50 military and civilian government personnel enthusiastically discovered that the course organizers had included a hands-on simulation exercise that demonstrated those sensors and techniques: a serious game that challenged players to use different types of sensors to locate a convoy transporting a mobile missile threat.

In this game scenario, called a red/blue experiment, a simulated (red) threat plays out in a virtual environment while the participants (the blue team) use simulated sensors and tools to make inferences about the threat and to decide upon courses of action. Known as serious because such games are educational tools, the ISR red/blue game was designed to emphasize material covered in the course lectures.

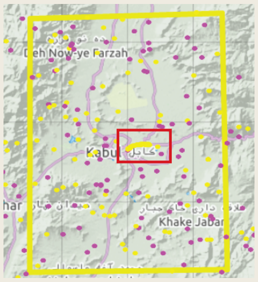
"The game allows the attendees an opportunity to apply the course concepts in a realistic situation and to see firsthand that data exploitation is hard!" said Carol Chiang, a technical staff member of the Laboratory's Intelligence and Decision Technologies Group and a lead developer of the game.

"The game is the outgrowth of many years of technical work in data management and simulation software systems, including many prior red/blue experiments, developed by the group since 2007," said Benjamin Landon, the assistant leader of the Intelligence and Decision Technologies Group. "The game's scenario is driven by the importance of locating mobile targets and the need for rapid decision making in response to identified threats."

During the afternoons of each full day of the two-and-a-half-day course, half the attendees engaged in gameplay while the other half attended seminars and demonstrations. The red/blue game began with a short briefing about the scenario and the tools available to players. The attendees, who were grouped into five teams, had 30 minutes to get acquainted with the tools and 10 minutes to discuss their strategy before they began the first of two 45-minute games. The game scenario, find the mobile target and stop the firing of a missile, was the same for both games, but the second game was complicated by having players contend with decoys and many "confuser" vehicles that were not part of the threat convoy.

"In 2018, we added multiple threat convoys. This addition was to make the game harder and more realistic than the first game that had only one target for the players to find," said Kenneth Mawhinney, another of the game developers. "The players couldn't just focus on monitoring one convoy but had to maintain awareness of a bigger picture."

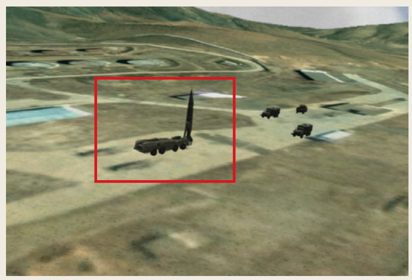
The game offered players the use of three technologies commonly employed in ISR missions: ground moving target indicator (GMTI) radar, synthetic aperture radar (SAR) imagery, and full-motion video (FMV). Chiang said the recommended utilization of the three modes of data acquisition was a sequence progressing from the use of GMTI flown over a region to determine movement indicative of a convoy, to the use of SAR images for



Step 1
Analyst scans ground moving target indicator (GMTI) radar. The dots identify something moving away from or toward the sensor.

Step 2
Analyst zooms in on cluster of dots and checks signal-to-noise ratio. A sliding timescale indicates the direction of vehicular movement.

Step 3
If vehicles are identified in GMTI data, analyst requests synthetic aperture radar (SAR) imagery for more focused view of vehicles.



Step 4
Analyst reviews full-motion video to positively identify the target.

The work flow depicted here for finding the threat convoy is illustrative of the sequence of tasks that analysts would employ in an actual search for vehicles moving over a broad landscape.

a more focused view of the suspected convoy once it has stopped, and then to an FMV scan to definitively identify one of the vehicles as the one carrying the missile.

Players could choose to task each of the three sensors multiple times. The GMTI radar returns reflected from objects on the ground were plotted on a map of the region; the track from subsequent GMTI sweeps indicated the direction in which the objects were moving. Each request for the SAR produced imagery that helped players refine their view of the objects they had found. The FMV simulation provided the best means of positively identifying the threat convoy, but FMV has a narrow field of view compared to the GMTI and SAR sensors. The mission teams have to use the GMTI and SAR sensors to effectively cue the FMV sensor rather than relying on FMV alone.

On the actual game days, each five-player team was assigned to a different space in which to play the game. Each team was allowed four computer setups. Chiang credits colleague Matthew Daggett with the advice to leave each team with fewer computers than players. “The game is organized around two main analytical tasks—the discovery of information and the integration of that information in order to make decisions. By their nature, the game computers are attractive to use, and everyone wants to see the data. We have found in testing similar serious games that if you give every player a computer, everyone plays the discovery role and no one is integrating information,” Daggett explained. “But if you remove a computer from one person, the team’s only means of ‘discovering’ information is to solicit teammates for information and integrate from that. By having N–1 computers for a team of N, you have the opportunity for a functioning team and not just N ‘analysts’ scanning the data.”

Players were given pregame time to plan a teamwork strategy. They might choose a leader who coordinated the tasking for each sensor mode and then connected the gathered information into an overall picture of the vehicles’ movements. A team could assign one member to each sensing job—searching GMTI data, analyzing SAR imagery, and scanning with the FMV—while the other two members monitored the outputs and kept track of the overall mission. Or, teams could work in pairs or trios to try out each sensor mode while keeping up a dialog about their analyses of the data they were collecting.

During the gameplay, a Lincoln Laboratory staff member was assigned to each team as an advisor. While these helpers followed the game action, they did not assess the effectiveness of a team's organization. However, one player commented that coordination of team roles was key to a team's success.

Development of the ISR game was an intense, two-month effort that required software development and integration, simulation design, and the setup of networks and computers specifically for use by the participants in the ISR course. The Lincoln Laboratory team creating the red/blue experiment was able to draw on software systems, simulations, networks, and displays built for many past projects in the Intelligence and Decision Technologies Group's portfolio. The team employed simulation tools that managed ground and air vehicle routes, interactive simulations, and software that emulated radar and optical sensors based on the underlying virtual world. From an array of components, which included systems for real-time data sharing, sensor simulations, and browser-based map displays and data viewers, the developers assembled a game scenario, tapping into expertise gained from staging red/blue experiments over the past 10 years.

The most challenging part of developing an engaging red/blue experiment was constructing a scenario that emphasized the technologies and techniques taught in the lectures while still providing a plausible ISR mission thread. Once the sensor modes for the simulation were selected, a scenario for the threat convoy and decoy vehicles was programmed into the simulation software. Next, the Lincoln Laboratory team had to select the level of difficulty for the game, including selecting the amount of simulated cloud cover, haze, and fog that could obscure the optical sensors, and the number of decoy vehicles in the scene. If the game was too easy, it would fail to illustrate the advantages and disadvantages of each sensor mode. Conversely, if the game was too hard, players would quickly lose interest and give up.

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The development team had enlisted volunteers to conduct trial runs of the game prior to the course. The iterative trials provided the team with feedback that allowed them to create games that could be managed within the short playing time, but still provide a difficult enough scenario to be challenging. "The level of difficulty was a challenge throughout the dry runs," Chiang said. "Some of the scenarios were too easy. Others were too hard, frustrating players who spent hours playing without finding anything. So rather than having players looking at FMV scans of haze and clouds for 90 percent of their time, we chose to make the game somewhat easy so players could apply the concepts they had just learned and get a result."

Red/Blue experiments are not just demonstrations for students at a course or exercises for military trainees. Researchers can use these experiments to study how humans approach the situations and problems simulated in the scenarios and how they use the new tools, sensors, and automation. Simulation experiments are much less expensive and take less time than fielding a new piece of technology to the military and then asking for feedback. Furthermore, because a red/blue experiment can be repeated in a laboratory setting, researchers can evaluate whether a new tool or analytic has the potential to make a difference to the operational community.

Lincoln Laboratory staff will apply lessons learned from the ISR game players' experiences and feedback to develop more complex scenarios and adapt the tools for use in not only future ISR games but also simulation experiments that may shed light on technologies the Laboratory is investigating. They will also be using the red/blue framework to demonstrate how machine learning techniques can be a benefit for command and control of autonomous systems and for data analysis.