

RDECOM's Intelligent Behaviors for Autonomous  
Systems:  
Ground/Air Cooperative Teaming for Countermine  
Modeling

RDECOM, STTC U.S. Army  
( Research, Development, and Engineering  
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## INTRODUCTION:

The Army has spent extensive time and effort into marking, and disabling land mines. The United States Army Engineer School (USAES) at Fort Leonard Wood, Mo. has been training soldiers in this field. The School shows soldiers how to search a field for land mines and what to do when a mine is encountered. One method of mine detection and marking requires a team of two soldiers that walk out in a field equipped with metal mine detectors in hand. The first soldier sweeps a small section of the field and then a second soldier follows and overlaps the area with a mine detector. The two soldiers perform this overlaying, sweeping action over the entire field until it is free from mines. This process takes a long amount of time and while sweeping a field for mines, some accidentally do get initiated and the soldier does not have enough time to clear the area before the mine detonates causing injury and sometimes death. There needs to be a better solution other than this method of mine detection and disabling.

Recently the Joint Robotics Program, a division of the Department of Defense and the Office of the Secretary of Defense, has been looking for a way to minimize and even eliminate the deaths and injuries of soldiers due to countermine activity. The Joint Robotics Program is a program that brings commercial and government entities together to realize how robotics can be used, as soon as possible, in the field and to take soldiers out of dangerous situations and use robots instead, therefore saving human lives. The program involves bringing the Army, Navy, Air Force, Marines, and commercial entities

together so that they can leverage existing technology and share ideas and current research into using robotics in the field to save soldiers from dangerous activities that could be performed by robots.

#### PREVIOUS WORK:

The JRP has funded previous entities including the AFRL ( Air Force Research Laboratory), INEEL(Idaho National Engineering Lab), SPAWAR(Space and Naval Warfare Systems), various Universities and other companies and government agencies with designing and implementing a ground robotic vehicle to identify and mark land mines in the field. Various entities have used commercial robotic vehicles and have worked on adding and equipping these robots with the sensors needed to detect and mark mines, some have developed physical robots needed to perform these tasks, and others have worked on software systems for the robots to perform the countermine tasks.

The techniques used range from tele-operation, using a robot that is controlled from a human user that is far away from the field to detect, mark, and/or disable the mine, to autonomous systems that detect, mark and/ or disable a mine on their own without human control at all. The robots used are various in control and capability and carry a vast array of different sensors and software to accomplish the goal of disabling a mine field and making it safe for soldiers to enter the field.

## A NEW APPROACH:

Recently the JRP has funded RDECOM (Research, Development and Engineering Command), STTC( Simulation and Training Technology Center) to develop software autonomous countermine behaviors and to use both an autonomous ground robotic vehicle along with an autonomous air vehicle, collaboratively teaming, to perform a countermine search and identification. The Intelligent Behaviors for Autonomous Systems department of RDECOM, designs and implements intelligent behaviors for autonomous systems in modeling and simulation environments and justifies the behaviors in the real world. The live and constructive models are used to show that these higher level behaviors work in the real world and are correlated with the simulation environment. The simulation work is implemented in OneSAF Testbed and is shown/accessed through an Operator Controller Unit. The behaviors are implemented on two iRobot ATRV-mini robotic platforms representing Small Unmanned Ground Vehicles (SUGV) one simulated “mother ship” representing an Unmanned Ground Vehicle (UGV), a simulated Unmanned Air Vehicle (UAV) and a real UAV. The real UAV chosen for this mission is a GoldenEye – 50 from Aurora Flight Sciences Corporation which is also a project that is being funded through DARPA (Defense Advanced Research Projects Agency).

After the operator designates an area to be searched and assigns the countermine task, the UGV plan a path and move to a location near the area to be searched. The area to be searched will be passed to the UAVs and SUGVs

and they will be launched. Because the real UAV cannot be launched from a simulated UGV, the collaborative effort includes the UAV starting up and hovering over a predefined area. Each UAV will plan its own path and move in a side to side sweep across the area. Using a camera positioned straight down, the UAV will detect and notify its corresponding SUGV and the UGV of any objects that are possible mines. The UGV will forward the coordinates to the OCU and plan a safe path to investigate each location. The iRobot will then identify whether or not there is an object at that coordinate and scan the area for objects using a SICK LMS Laser. Once the area has been scanned, the SUGV will determine whether or not a “simulated” mine was found, and relate that information back to the OCU. This method will be repeated until all possible “simulated” mine locations have been investigated and reported.

This method of coordinated air and ground robotic behaviors for mine detection is a solid base for modeling a real scenario. The initial work is to only provide a model to start with. The SICK laser is used to scan objects that are only mimicking mines. The mimicked mines will have to be tall enough to be seen by the SICK laser. A real mine would not be found. RDECOM is working on composable behaviors that can be used on any platform and with any sensors. The bases of this work is not to develop hardware to detect actual mines but to show that air to ground coordination behaviors can be developed regardless of hardware and sensors. The capability of the behaviors being written and adapted to any platform and work with any sensor is an important mission. The higher level behaviors will serve to work jointly with lower level behaviors, independent

platforms, and a vast array of sensors. The higher level behaviors will help robots to accomplish mission specific tasks and not just lower level tasks therefore enabling them to not have to be programmed for every individual mission but these behaviors to be transported from one platform to another to accomplish any task given to the robot with little programming involved in between missions. The work that RDECOM is performing is initial work. The behaviors developed in the testbed show that mines can be found and marked in simulation. The simulation behaviors were demonstrated at Virginia International Raceway . These behaviors can be programmed on real robots with the same goals being met and results being accomplished. The M&S Live/Virtual/Constructive testbed being developed at the STTC provides an optimal Environment to explore various concepts for the employment of unmanned systems in the battlespace. Future work will include changing platforms, showing behaviors with different sensors, getting the robots to physically mark land mine locations on the physical earth as well as in simulation, and future work could include disabling the mines, once found and identified as real mines.

#### ISSUES:

One key issue that RDECOM is dealing with recently is that of localization. The ARTV-mini's position with respect to the start-up location given by the on-board encoders is not accurate. For the recent demonstrations, reference markers have been used to help the SUGV to know its position. As long as the

SUGV can see at least one of its reference markers, it knows where it is located and its orientation. Using two reference markers greatly helps reduce the error resulting from incorporating the previous location and orientation. The idea of using wireless access points has been investigated. The idea of triangulating access point to broadcast position has been observed. The recent idea is to use DGPS (Differential Global Positioning Systems) to find the position and heading of the robot. The DGPS system will have to have an accuracy of 0.5 meters. Along with a compass the navigation system will give heading and position. The issues are that with this navigation system, the robots will have to work outside and will have to be able to accurately track satellites at all times of the day. A localization solution is preferred that will allow the robots to work indoors as well as outdoors and will not rely on tracking satellites. New technologies are being considered but are not available for the recent time frame. Another demonstration is scheduled for the August time frame to show the coordination between the SUGV and UAV. Both systems will need to have accurate sensing for the behaviors to truly perform there best.

#### CONCLUSION:

The work that is being performed by RDECOM and its' contracted companies is important work that is desperately needed for the war fighter today. Soldiers are becoming injured and dying in tasks that could be performed by robots, therefore taking human lives out of harms way. The countermines mission

is a very important area that robotics would be very useful for. RDECOM is working very hard to ensure that their LVC Testbed and intelligent behavior development for autonomous systems both supports the war fighter, and helps out the families of the war fighter by reducing the danger to our soldiers.

RDECOM is also working hard to ensure that these behaviors are useful and can be adapted to other departments and areas to help advance robotics and robotic users. The simulation environment provides a low cost, effective mechanism for evaluating the efficacy of the developed behaviors and their application to mission critical and dangerous tasks to the warfighter. The M&S testbed also provides a mechanism for the evaluation and analysis of the effectiveness of these behaviors for accomplishing the specified missions as well as the effectiveness of the warfighter in accomplishing his tasks using unmanned systems. The countermine mission is an important mission that RDECOM STTC contributes to by developing behaviors that will greatly benefit the warfighter by taking him out of harm's way as well as providing insight into the mission effectiveness of utilizing unmanned systems in accomplishing critical mission tasks.