Unmanned Ground Vehicles: Technological Innovations for Civilian and Military

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Unmanned ground vehicle (UGV) is a project on Robotics. The vehicle operates without an onboard human presence. UGVs can be used for many purposes where it may be inconvenient, dangerous, or impossible to have a human operator present. The vehicle will have a set of sensors to observe the environment, and will either autonomously make decisions about its behavior or pass the information to a human operator at a different location who will control the vehicle through tele-operation. Unmanned Ground Vehicles (UGVs) will undoubtedly play a crucial role in military land operations in future. The integration of combat vehicles and autonomy is important to prevent loss of life during combat situations. Moreover, integration among different autonomous systems as a part of a unified platform for military innovation is the future of the battlefield. The UGV era is yet to reach its full potential and is presently in a latent phase. However, the geopolitical events and conflicts happening across the globe have allured the revolutionary potential of unmanned systems, due to which there is a renewed hype for the UGVs with accelerated advancements in robotics technology, artificial intelligence and machine learning. In addition, UGVs do not require a large industrial set-up as components and systems are now available commercially, however, there are still adoption challenges for militaries related to doctrines and tactical support systems.

The UGV is the land-based counterpart to unmanned aerial vehicles and unmanned underwater vehicles (UUVs). Unmanned robotics is being actively developed for both civilian and military use to perform a variety of dull, dirty, and dangerous activities. A working remote controlled car was reported in the October 1921 issue of RCA's World Wide Wireless magazine. The car was unmanned and controlled wirelessly via radio; it was thought the technology could someday be adapted to tanks. In the 1930s, the USSR developed Teletanks, a machine gun-armed tank remotely controlled by radio from another tank. These were used in the Winter War (1939-1940) against Finland and at the start of the Eastern Front after Germany invaded the USSR in 1941. During World War II, the British developed a radio control version of their Matilda II infantry tank in 1941. Known as "Black Prince", it would have been used for drawing the fire of concealed anti-tank guns, or for demolition missions. Due to the costs of converting the transmission system of the tank to Wilson type gearboxes, an order for 60 tanks was cancelled. From 1942, the Germans used the Goliath tracked mine for remote demolition work. The Goliath was a small tracked vehicle carrying 60 kg of explosive charge directed through a control cable. Their inspiration was a miniature French tracked vehicle found after France was defeated

in 1940. The combination of cost, low speed, reliance on a cable for control, and poor protection against weapons meant it was not considered a success. The first major mobile robot development effort named Shakey was created during the 1960s as a research study for the Defense Advanced Research Projects Agency (DARPA). Shakey was a wheeled platform that had a TV camera, sensors, and a computer to help guide its navigational tasks of picking up wooden blocks and placing them in certain areas based on commands. DARPA subsequently developed a series of autonomous and semi-autonomous ground robots, often in conjunction with the U.S. Army. As part of the Strategic Computing Initiative, DARPA demonstrated the Autonomous Land Vehicle, the first UGV that could navigate completely autonomously on and off roads at useful speeds.

DESIGN: Based on its application, unmanned ground vehicles will generally include the following components: platform, sensors, control systems, guidance interface, communication links, and systems integration features.

PLATFORM: The platform can be based on an all-terrain vehicle design and includes the locomotive apparatus, sensors, and power source. Tracks, wheels, and legs are the common forms of locomotion. In addition, the platform may include an articulated body and some are made to join with other units.

SENSORS: A primary purpose of UGV sensors is navigation, another is environment detection. Sensors can include compasses, odometers, inclinometers, gyroscopes, cameras for triangulation, laser and ultrasound range finders, and infrared technology.

CONTROL SYSTEMS: Unmanned ground vehicles are generally considered Remote-Operated and Autonomous, although Supervisory Control is also used to refer to situations where there is a combination of decision making from internal UGV systems and the remote human operator.

REMOTE OPERATED: A remote-operated UGV is a vehicle that is controlled by a human operator via interface. All actions are determined by the operator based upon either direct visual observation or remote use of sensors such as digital video cameras. A basic example of the principles of remote operation would be a remote controlled toy car.

FIGURE 1: UNMANNED GROUND VEHICLE (UGV) IS A PROJECT ON ROBOTICS.

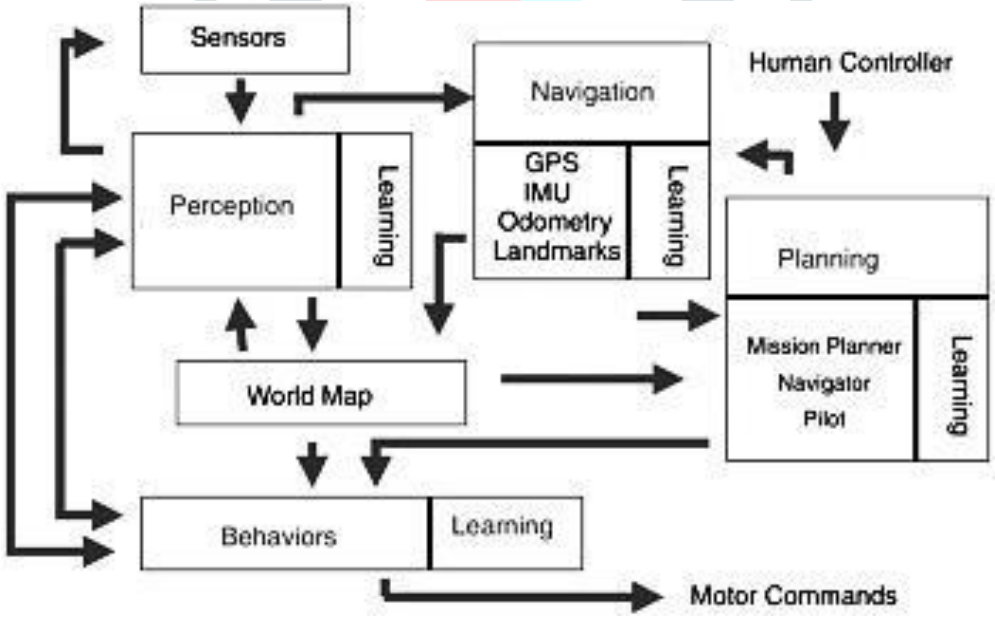

FIGURE 2: RELIABLE OPERATIONS OF UGVs.

An autonomous UGV (AGV) is essentially an autonomous robot that operates without the need for a human controller on the basis of artificial intelligence technologies. The vehicle uses its sensors to develop some limited understanding of the environment, which is then used by control algorithms to determine the next action to take in the context of a human provided mission goal. This fully eliminates the need for any human to watch over the menial tasks that the AGV is completing. A fully autonomous robot may have the ability to:

1. Collect Information about the Environment, such as Building Maps of Building Interiors.
2. Detect Objects of Interest such as People and Vehicles.
3. Travel between Waypoints without Human Navigation Assistance.
4. Work for Extended Durations without Human Intervention.
5. Avoid Situations that are harmful to People, Property or itself, unless those are Part of its Design Specifications.
6. Disarm, or Remove Explosives.
7. Repair itself without Outside Assistance.

A robot may also be able to learn autonomously. Autonomous learning includes the ability to:

1. Learn or Gain New Capabilities without Outside Assistance.
2. Adjust Strategies Based on the Surroundings.
3. Adapt to Surroundings without Outside Assistance.
4. Develop a Sense of Ethics Regarding Mission Goals.

Autonomous robots still require regular maintenance, as with all machines. One of the most crucial aspects to consider when developing armed autonomous machines is the distinction between combatants and civilians. If done incorrectly, robot deployment can be detrimental. This is particularly true in the modern era, when combatants often intentionally disguise themselves as civilians to avoid detection. Even if a robot maintained 99% accuracy, the number of civilian lives lost can still be catastrophic. Due to this, it is unlikely that any fully autonomous machines will be sent into battle armed, at least until a satisfactory solution can be developed.

GUIDANCE INTERFACE: Depending on the type of control system, the interface between machine and human operator can include joystick, computer programs, or voice command.

COMMUNICATION LINKS: Communication between UGV and control station can be done via radio control or fiber optics. It may also include communication with other machines and robots involved in the operation.

SYSTEMS INTEGRATION: Systems architecture integrates the interplay between hardware and software and determines UGV success and autonomy.

TECHNOLOGICAL APPLICATIONS FOR CIVILIAN AND MILITARY: There are a wide variety of UGVs in use today. Predominantly these vehicles are used to replace humans in hazardous situations, such as handling explosives and in bomb disabling vehicles, where additional strength or smaller size is needed, or where humans cannot easily go. Military applications include surveillance, reconnaissance, and target acquisition. They are also used in industries such as agriculture, mining and construction. UGVs are highly effective in naval

operations, they have great importance in the help of Marine Corps combat; they can additionally avail in logistics operations on to the land and afloat. UGVs are also being developed for peacekeeping operations, ground surveillance, gatekeeper / checkpoint operations, urban street presence and to enhance police and military raids in urban settings. UGVs can "draw first fire" from insurgents-reducing military and police casualties. Furthermore, UGVs are now being used in rescue and recovery mission and were first used to find survivors following 9/11 at Ground Zero. The applications of UGVs in various areas have been mentioned below.

- Space Applications
- Civilian and Commercial Applications
- Agriculture
- Manufacturing
- Mining
- Supply Chain
- Emergency Response
- Military Applications

EXAMPLES OF UNMANNED GROUND VEHICLES: The examples of UGVs have been mentioned below.

- SARGE
- Multi-Utility Tactical Transport
- X-2
- The Warrior
- TerraMax
- THeMIS
- Type-X
- The Talon
- SWORDS
- Small Unit Mobility Enhancement Technology (SUMET)
- Autonomous Small Scale Construction Machine (ASSCM)
- Taifun-M
- UKAP
- Ripsaw

CHALLENGES AND OPPORTUNITIES: The development path of UGVs is still very challenging and problematic. Due to its autonomous nature, many factors are involved in raising societal impacts and technological and ethical concerns. One of the biggest challenges with autonomous vehicles is technology advancement, which is not at the stage where the perception of the environment is entirely predictable, and there are still many unforeseen dangers involved with it. Some other challenges include lack of communication technology, planning and policies and regulations. The maintenance of security and integrity of such systems is highly vulnerable and needs to be addressed. The policymakers need to streamline structure and regulate the autonomous system considering its diverse nature of vehicles, their operating constraints and capabilities. The autonomous segment in UGVs will certainly see the highest growth in the defence sector with the increased use of small UGV and smart robots for military combat. These systems will have advanced AI, ML, and autonomous

navigation capabilities that will allow UGVs to manoeuvre from pre-programmed locations and follow army convoys. The growth will be attributed to the growing defence needs and budgets and the increasing procurement of advanced robots for military operations. India needs a collaborative effort from all stakeholders, for which the Indian government needs to regularize and come up with a firm policy for autonomous vehicles. India has enunciated the indigenous development of combat systems and weapons with DRDO and its affiliates, and military-civil fusion will be a significant acolyte in this for the future of India's defense set-up. UAVs will be an indispensable part of our lives, and therefore, it is necessary to understand the future technology needs of the military, as the future battlefield will be a rundown of high tech enabled unmanned systems that will overcome the challenges of sustaining legacy forces and keeping human combatants safe from harm's way.

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