UNMANNED GROUND VEHICLES: TECHNOLOGY ECOSYSTEM IN INDIA

ANEES AHMED explains how UGVs are getting employed in wide range of mission critical applications because of their ability to manoeuvre in different terrains, be it deserts, mountains or high-altitude areas

Russian-made Uran-9 tracked unmanned combat ground vehicle (UCGV)

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Defence sector worldwide is striving to stay ahead of technology disruption. They are increasingly embracing various disruptive technologies to modernise their forces, providing them with a much-needed edge. While most of the major automotive players' focus is on autonomous passenger vehicles or semi-autonomous vehicles, there was a huge void in utilising these futuristic technologies for defence and homeland security applications. However, the last decade witnessed various automotive technologies getting matured and proving to be highly reliable and robust in various environmental conditions. This development has incentivised the defence segment to adopt these technologies to build advanced, intelligent defence solutions. Unmanned Ground Vehicle (UGV) is one of the modern-era frontline combat platforms that has taken the favourite list of forces across the globe, including India.

According to Fortune Business Insights, the global unmanned ground vehicle market is expected to grow from $2.73 billion in 2021 to $4.34 billion in 2028 at a CAGR of 6.82 per cent. Introduction of Artificial Intelligence to develop smart and intelligent autonomous platforms has been a breakthrough in the domain. The increasing demand for autonomous platforms among defense forces and industrial sector are the key growth drivers for unmanned ground vehicle market.

What is an unmanned ground vehicle?

A simple definition for UGV is that it is a ground vehicle that can run independent of a human operator. UGVs use an array of sensors to observe and cognize the environment around it, while various drive by wire actuators and motors perform the operational role.

The advancement in detection sensors, signal processing engines and the availability of high-performance computer platforms are enabling rapid advances in this segment. In contrast to aerial and surface autonomous platforms, the ground-based platforms may confront higher challenges during a mission, not only due to the complex terrains they operate on, but also the frontier they belong to. UGVs are typically exposed to highly vulnerable and unpredictable environment with numerous unknown obstacles, which brings in a lot of complexities and design consideration during the process of development.

DRDO Daksh electric-powered remote-controlled robot

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Indian UGV scenario

The Indian Army has recently conducted a UGV Strike Event at Babina Army Range in Uttar Pradesh, inviting industry to showcase their technological capabilities in autonomous systems. This is a great news for technology innovators in the domain as India plans to beef up its presence across the border, and the forces are looking out for modern technologies to aid them in the frontline battlefield.

DARPA, a research and development agency of the United States Department of Defense, responsible for the development of emerging technologies, initiated 'DARPA Grand Challenge' in 2004, a revolutionary programme aimed at bridging the gap between fundamental discoveries and military use. Since 2004, winners of the event have been funded by DARPA for further research and development. The UGV strike event, conducted by the Indian Army, was similar to the DARPA Grand Challenge, and we can expect more such industry interaction programmes in the coming years.

The recent push to induct unmanned ground vehicles is majorly aimed at the northern borders aiding in 24x7 surveillance, tactical reconnaissance and enable them to launch quick combat missions, deliver critical supplies, and carry out rapid evacuations during a conflict.

India realised the potential of unmanned platforms in 1990s and initiated various projects under DRDO Labs across the country. Labs such as Centre for Artificial Intelligence & Robotics (CAIR), Research & Development Establishment Engineers (R&DE), Vehicle Research & Development Establishment (VRDE) and Combat Vehicles Research & Development Establishment (CVRDE) have been in the forefront, leading the R&D efforts for the indigenous development of UGVs.

India is at a threshold now. DRDO has already introduced several remotely operated platforms for various missions. DAKSH, NETRA, DAKSH MINI, DAKSH-SCOUT, UXOR MUNTRA-N are some of the unmanned platforms already fielded by DRDO for various purposes such as explosive device identification and handling, surveillance, extract suspected objects with telescopic manipulator arms, detect and diffuse unexploded ordnance, unmanned NBC reconnaissance missions (nuclear, biological, chemical), etc.

Technologies behind UGVs

Unlike an autonomous vehicle that navigates on a highly refined city road or a highway, UGVs, designed for military missions, operate in a complex and unknown terrain. Each mission may have entirely different terrains, different goals and magnitude. The question is, how do you build a machine that adapts itself to different terrains or a platform that is multi-mission ready? The modern technologies like AI, ML, Vision Analytics, etc. keep these platforms up and running in any complex situations. The ever-evolving powerful and sophisticated algorithms and compute engines ensure performance under extreme conditions, sense and interpret the surroundings to overcome obstacles, and trigger weapon systems and assigned missions with self-learned intelligence.

Guardium UGV used by the Israel Defence Forces to operate as part of the border security operations

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Software and mechanicals

Software for autonomous platforms is always an expensive affair — be it for a small robotic machine or an advanced airborne or ground system. There are various MIL qualified software packages and RTOS platforms available in the market which are compatible with advanced computing engines. Nevertheless, developers can also build high-quality software packages using various open-source software tools in the market. Robot Operating System (ROS), Open Layers, OpenStreetMap, LAMP, Autonomous Navigation Algorithms are some of the popular tools that can be implemented in Autonomous platforms. While ROS is a flexible, opensource platform for developing Robot software, OpenLayers, OpenStreetMap and LAMP are maps and navigation tools that aid integration of dynamic maps in the autonomous vehicle. Developers can build web-based GIS system and integrate it with the ROS, along with various algorithms to identify and define the path of the vehicle and turn by turn navigation support.

Autonomous vehicles rely on navigation technologies, sensors and cameras to navigate through a terrain. Autonomous navigation comprises of three important algorithms — algorithms for geo-localisation, path planning and navigation. These sophisticated navigation algorithms help the platform to detect and identify obstacles, avoid them, calculate best routes and define a new path for the vehicle by understanding the surroundings — all based on the data from various sensors.

The vehicle platform is one of the key components of UGV. UGVs can be realised using IC engine or electric platforms. Owing to the peculiar UGV applications in defence environment, electric platforms are considered suitable as it helps surmount several mechanical customisation challenges of an IC engine platform and allows easy access to vehicle network for obtaining data such as engine status, fuel status, acceleration,

Milos unmanned ground vehicle for the Serbian armed forces

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breaking, and so on. An electric platform also brings in advantages like minimal heat signature, low noise, lesser vibration and relatively less weight. A UGV platform designed or chosen for defence applications need to support at least a 500kg payload, in addition to the weight of all electronics and sensors integrated into the system, considering the typical applications like emergency evacuation, payload/arm delivery, etc.

Drive-by-wire, also known as X-by-wire, is another technology transforming vehicle. Drive-by-wire rely on vehicle electronics and various sensor inputs to control the operations such as steering, acceleration and braking. The Drive-By-Wire System receives the commands sent by the Control CPU (UGV may have multiple CPUs running various functions) and generates the necessary command signals for steering and sends these signals to the actuators to trigger vehicle's movement and turns.

Vehicle Communication Network, another important component, connects the in-vehicle electronics, devices and vehicle by itself to external world over CAN, Ethernet, WIFI, Mesh Network, Satellite Communication, etc. A reliable and redundant communication network structure is key as it handles huge amount of high-speed data from several sensors and processors. Gigabit-speed networks are recommended as they provide high-bandwidth, low-latency, and high-reliability links, paving the way for real-time autonomous operations.

Navigation sensors

As mentioned above, UGVs rely on sensors for autonomous operation. Millimetre Wave Radars, LiDAR's, Cameras (IR and Optical), Ultrasonic Sensors, GPS-INS are some of the key sensors employed on a UGV. These platforms basically use GPS & IMU for localisation and navigation, and the perception sensors to perceive surrounding environment. These sensors sense the surroundings and provide crucial data for safe and reliable autonomous vehicle operations such as obstacle detection, proximity warnings and collision avoidance, lane departure warnings and adaptive cruise control, accurate vehicle location, among others.

Mission payload configuration

Unmanned ground vehicles integrate multitude of payloads, based on the mission and application it is built for. Identifying payload needs is critical to an autonomous surveillance vehicle as the weight impacts the range and manoeuvring capabilities. Typically, UGVs will have several surveillance sensors as a standard configuration. It may include Thermal Cameras, PTZ cameras or 360 degrees bird-eye-view cameras to survey the surroundings and communication systems, communication network, search lights, control consoles, etc. for command and control. Additional mission-specific payloads may include weapons, short-range/medium-range rifles, grenade launchers, barrel cameras, casualty evacuation racks, radio communication, emergency supply kits, logistics support basket mounts, IED/mine detection equipment, CBRN detection systems, etc.

Remote operator console

UGVs are classified broadly into two types — autonomous and remotely operated. While remotely operated vehicles are commanded by a human from a remote operator console, mostly all autonomous platforms will also have a remote station to take the control of the vehicle during an emergency or in case of a change in mission. Remote operator consoles receive various status reports on vehicle, surveillance data and other critical information as intended. Hence, teleoperator consoles or remote operator consoles are key to any autonomous vehicle. They act as a remote command centre and facilitates gathering of crucial intelligence.

These consoles are equipped with reliable, communication and control systems, wherein the operator can take a remote control of the vehicle at any point of time, control the surveillance payload, make emergency announcements, start or stop the vehicle, and so on. The teleoperator console can be integrated to an existing command-and-control centre or it can be a portable kit that features intuitively designed web applications for configuring missions and teleoperating the vehicle. Typically, teleoperator consoles establish a telemetry data link with the vehicle.

Role of AI in unmanned platforms

Artificial Intelligence has been primarily associated with scientific and technological evolutions outside the defence spectrum. The technology that enables intelligent execution of tasks in machines, however, is now key to any modern defence platforms; not limited to autonomous vehicles; establishing itself as a robust solution for future evolutions. AI is finding its way to a plethora of defence applications such as advanced weaponry systems, command-and-control systems, military equipment logistics and maintenance, training and development, battlefield simulations, autonomous vehicles including land, surface and aerial among others. Integration of AI-powered vision analytics in various defence applications helps in object detection, classification and advanced image processing and enhancements in a highly cluttered environment.

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AI enables:

- Effective control and manoeuvre of advanced technologies.
- Helps accurate detection, identification and recognition of targets in complex combat environments.
- More efficient command and control with data-driven, automated systems.
- Helps build advanced war simulation for training and strategic planning.
- Enables autonomous weapon systems.
- Advanced processing & analysis of high volume, dynamic and multi-source data.
- Provides crucial strategic insights through real-time predictive data analysis.
- Reduces officer's workload during data interpretation and help them focus on core functions.
- Enables quick and efficient decision making during a conflict with greater efficiency.

Artificial Intelligence is complemented by the ever-increasing availability of high-performance compute engines, GPUs, high-speed communication technologies and advanced signal processing systems, heavily augmented by machine learning (ML). The integration of Artificial Intelligence is bringing much-needed autonomy to multitude of military applications, especially UGVs, UAVs, unmanned remotely operated tanks, underwater unmanned surveillance platforms, automated firing systems, cross-border surveillance among others.

UGV applications

From acting as frontline battlefield warriors to combat missions; logistics and delivery of critical supplies to emergency evacuation, IED search-detect-and-destroy missions, reconnaissance and surveillance UGVs are getting employed in wide range of mission critical applications. The ability of these platforms to manoeuvre in different terrains, be it a desert, mountain or high-altitude areas, make them a preferred choice for troops in the frontline.

To sum up, technologies are revolutionising the battlefield by enabling game-changing weapons and warfield support systems. In the recent past, India has shown higher focus in modernising forces with latest technologies, which is expected to help us sail ahead of our counterparts in coming years. The government, especially Defence Ministry and policymakers, need to further look into the possibilities of expanding the scope of inducting modern technologies and establish a better and stronger connect with technology innovators in the country. The recent decision of the Ministry of Defence (MoD) inviting non-governmental parties to demonstrate their UGV capabilities has given a new dimension to government's effort. India has 8000 plus defence SMEs. If the government can come up with a plan to maximise their involvement and utilise this massive talent and research facilities with timely funding assistance and shorter turnaround time, we can keep our forces updated and future ready.

The author is Founder & President of Mistral, a leading company in the embedded technology and defence domain. With over 30 years of exposure to India's Defense and Homeland Security domain, he is also an active member of Entrepreneurs Organisation (EO) and Young Presidents Organisation (YPO)