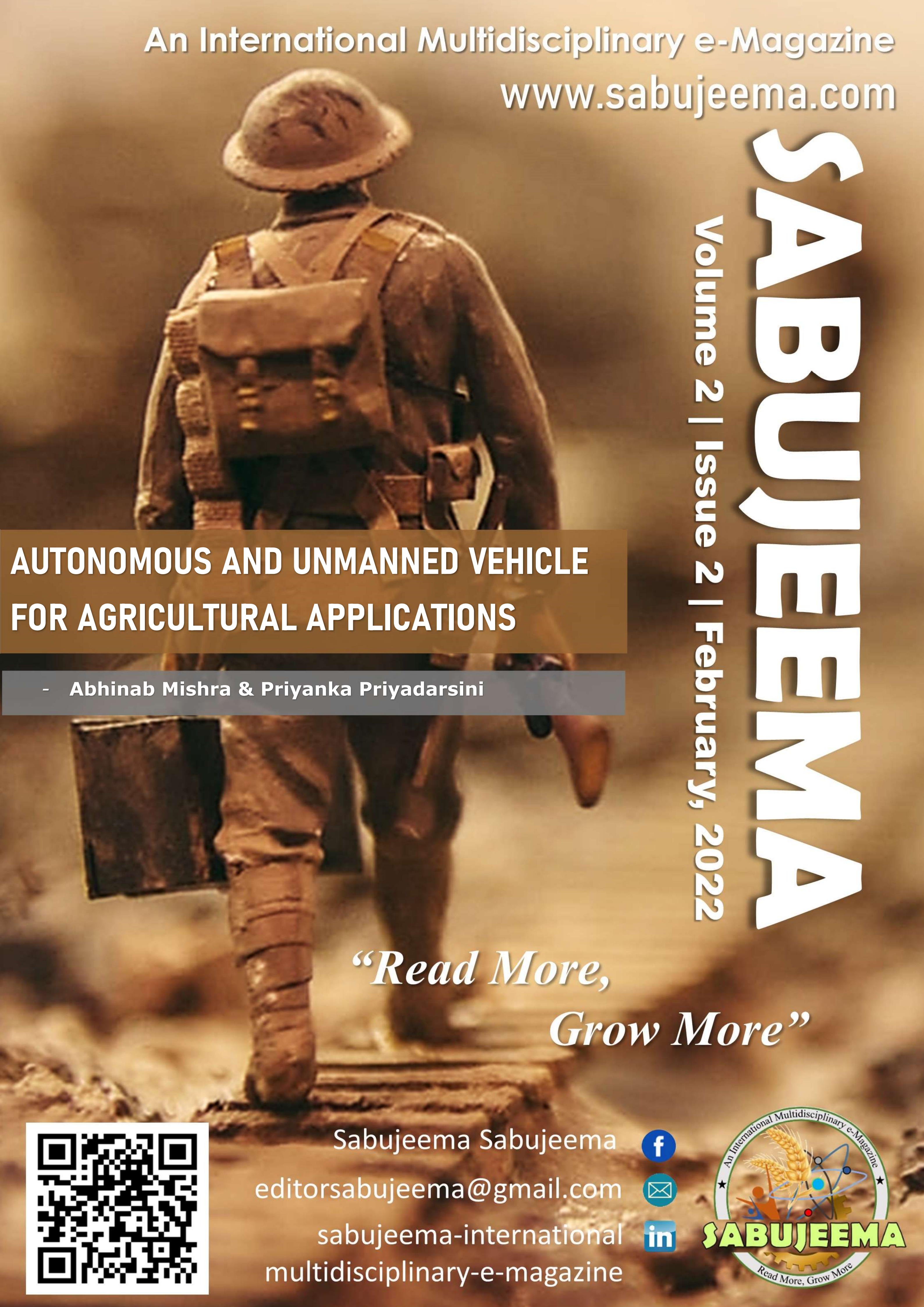

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- Abhinab Mishra & Priyanka Priyadarsini

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Autonomous and Unmanned Vehicle for Agricultural Applications

Abhinab Mishra
Assistant Professor, SoA, GIET University, Gunupur.

Priyanka Priyadarsini
Ph.D Scholar, College of Agril. Engg. & Technology, OUAT, Bhubaneswar.

INTRODUCTION

It is estimated that we need about 70% more food in 2050 than we have today in order to provide every one of the 9.6 billion world population with a daily intake of 3,000 calories. Addressing the challenges of feeding the growing world population with limited resources requires innovation in sustainable, efficient farming. The digitization of agriculture holds promise for meeting demands of increased food production, addressing social concerns about animal welfare, enabling livestock traceability, and minimizing the environmental impact of livestock production while building resilience and adaption to climate change. This new frontier of innovation in farming, becoming known as the smart farming future, is made possible through technological change involving continuous improvement in sensors, information and communications technologies (ICT), advances in data storage and analytics made possible with the Internet of Things (IoT), Cloud-based systems and ultimately the acceptance by farmers of digital technology tools for use on their farms. Digital technologies create new possibilities for innovation, making it possible for today's farmers to be more efficient, effective and economically successful than ever before while providing a new way of addressing persistent problems in commercial agriculture.

The practice of precision agriculture offers many benefits towards addressing these challenges, such as improved yield and efficient use of such resources as water, fertilizer and pesticides. An unmanned aerial vehicle (UAV) and an unmanned ground vehicle (UGV) are the powerful tool for site-specific farming management. The autonomous machines can reduce the need for skilled labour in agriculture and perform field operations. Automation of farm operations can further empower farmers to remain active on farms by addressing the critical constraint of severe labour shortages in the agriculture sector.

UNMANNED AERIAL VEHICLE

An Unmanned Aerial Vehicle (UAV) is a type of aircraft that operates without a human pilot on-board. There are different types of UAVs employed for different purposes. Originally, the technology was employed by the military for anti-aircraft target practice, intelligence gathering and surveillance of some enemy territories. The technology has however grown beyond its initial purpose and in recent years has gained prominence in different spheres of human endeavour. Advancements in technology has allowed for the increased adaptation of unmanned aerial vehicles for various purposes. There is a huge potential for the application of UAVs in Agriculture. One such application is in accurate and evidence-based forecasting of farm produce using spatial data collected by the UAV. UAVs in combination with GPS and GIS can reveal many issues on the farm, common among which is irrigation related problems, soil variations, fungal and pest infestations. Further information relating to water access, changing climate, wind, soil quality, the presence of weeds and insects, variable growing seasons, and more can all be monitored with UAVs. Utilizing the information gathered, farmers can provide fast and efficient solutions to detected problems and issues, make better management decisions, improve farm productivity, and ultimately generate higher profit.

MACHINE VISION

Machine vision sensors measure the relative position and heading using the image sensor mounted on the vehicle. There are several aspects of machine vision based sensing. Different types of sensor modalities can be selected to measure the guidance information. Weed detection is one of the application, Optical sensors is used to map and/or spray weed patches present in fallow sites and in various wide-row crops. An ultrasonic distance sensor in combination with optical sensor is used for the determination weed detection based on plant heights. Ultrasonic sensors provide a distance measurement based on sound waves with frequencies above human hearings range. The measured travel time of an ultrasonic pulse from the emitter to the object reflecting the pulse back to the sensor is proportional to the distance. It was hypothesized that the weed infested zones have a higher amount of biomass than non-infested areas and that this can be determined by plant height measurements.

GLOBAL POSITIONING SYSTEM (GPS)

GPS-based navigation systems are the only navigation technologies that have become commercially available for farm vehicles. Many tractor manufacturing companies now offer the Real-Time Kinematic (RTK) GPS based auto steering system as an option on their tractors. The position information from the RTK GPS can be used for both guidance and other applications such guidance systems is that they can be easily programmed to follow curved rows.

There appear to be three limitations to using GPS for vehicle guidance. GPS cannot promise consistent positioning accuracy in the range of centimetres for a variety of field conditions (e.g., presence of buildings, trees or steeply rolling terrain, and interruption in satellite or differential correction signals). The second limitation is the inherent time delay (data latency) required for signal processing to determine locations that might present control system challenges at higher field speeds. The third is the high cost for agricultural application (although there is a consistent trend of cost reduction with widespread use). However, with the anticipated technology developments, these limitations will undoubtedly be overcome, thereby making GPS a choice candidate for incorporation into vehicle guidance systems.

LASER-BASED SENSORS

Laser-based sensors have a relatively longer range and higher resolution. The guidance systems need three or more reflectors (landmarks) around the work field. The time at which the laser beam is detected is communicated to the guidance system, which uses triangulation to define the location of the vehicle. The system is insensitive to environmental conditions, e.g., strong light change for machine vision and microwave shadowing for GPS, which will make the system inoperable. However, laser-based sensor systems have two drawbacks. They do not work well if the position is changed for any of the artificial landmarks.

GEOMAGNETIC DIRECTION SENSOR (GDS)

A geomagnetic direction sensor (GDS) is a magnetometer that senses the earth's magnetic field. It can be used as a heading sensor similar to an electronic compass. The GDS is generally used to supplement other sensors. Researchers have used GDS to provide heading information to a tillage robot. GPS with GDS for vehicle guidance along straight directional lines. One limitation of GDS sensors is the influence of external electromagnetic interference from the outside environment, such as from a nearby set of high-tension electrical wires or the vehicle heater/air conditioner fan. However, by controlling these error sources, they were able to combine GDS with a medium-accuracy GPS system (20 cm) and track a straight line with an average error of less than 1 cm.

CONCLUSION

With the emergence of new technologies in the industry, research into their application to agricultural vehicle guidance systems will contribute to the realization of autonomous agricultural vehicles or robots in the future. Although the research developments are abundant, there are some shortcomings (e.g., low robustness of versatility and dependability of technologies) that are delaying the improvements required for commercialization of the guidance systems. It can be concluded that both GPS and machine vision technologies can be 'fused' together as the trend development for agricultural vehicle guidance systems. The application of new popular robotic technologies for agricultural guidance systems will augment the realization of agricultural vehicle automation in the future. On the other hand, UAVs that are well suited for Agriculture use are expensive including operation and maintenance cost. It is therefore often difficult to convince farmers and Agriculture related stakeholders to integrate UAVs into their business. Beyond cost, battery limitations, safety and legal related issues are still major hurdles that need to be scaled before UAVs can find a strong foothold in agriculture.