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Design and implementation of robotic platform; RoboTurk

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ABSTRACT

Detecting and collecting data from field are repetitive and time-consuming tasks. Agricultural robots would help the automation of these tasks such as gathering data from the field and transferring it to a DSS. One of the core elements of ICT – AGRI Robofarm project is to design one prototype autonomous robotic platform (RoboTurk) which will carry on several sensors and it will be able to perform agricultural tasks. In this paper a novel mobile robot will be demonstrated. The designed vehicle can be operated in open and closed field conditions and can carry several sensors such as hyper spectral camera for detecting field phenomena. In the future it will be able to have installed some implements, as: a spray system for variable spraying, a lifting platform to perform seeding, etc. The autonomous navigation, is been achieved with the use of a laser scanner and a RTK-GPS system.

Keywords: **A**gricultural robot, robofarm, RoboTurk

1. INTRODUCTION

Nowadays, the international practice in order to face the problems of increased agricultural production, tends to use more and more advanced technologies that can be used by the farmers, as tools for managing the farm. However, the use of intelligent and complicated systems in the open and dynamic environment of a field is a big challenge. Over the last decades, there is a growing trend on the design and manufacture of automated vehicles for more intelligent management mostly for high value crops. The development of small autonomous tractor can change the farming techniques in targeted operations such as micro-tillage, micro-spraying, selective harvesting and reseeding.

The autonomous vehicles could work day and night, be weather independent and be adaptable to different field environments. The main aim of this paper is to describe the development of a robotic platform (RoboTurk), suitable for open-field environments, able to carry sensors and to communicate with the Software Architecture for Agricultural Robots -SAFAR (http://www.unibots.com/SAFAR.htm) software. RoboTurk's main characteristics are (Figure 1):

- It has several ways of controlling methods, such as wireless joystick and access point connection in 5 km range from farm office
- Receives *.xml files generated by Safar software and will complete tasks in fully autonomous mode
- Four wheel drive and steering system for dynamic manoeuvre capability and for adoption of all field constraints in term of obstacles
- Operation in parcels with crops planted in rows autonomously based on Global Positioning System, and/or with using a laser scanner row detection system.
- All operational data automatically is transferred to a Farm Management Information System

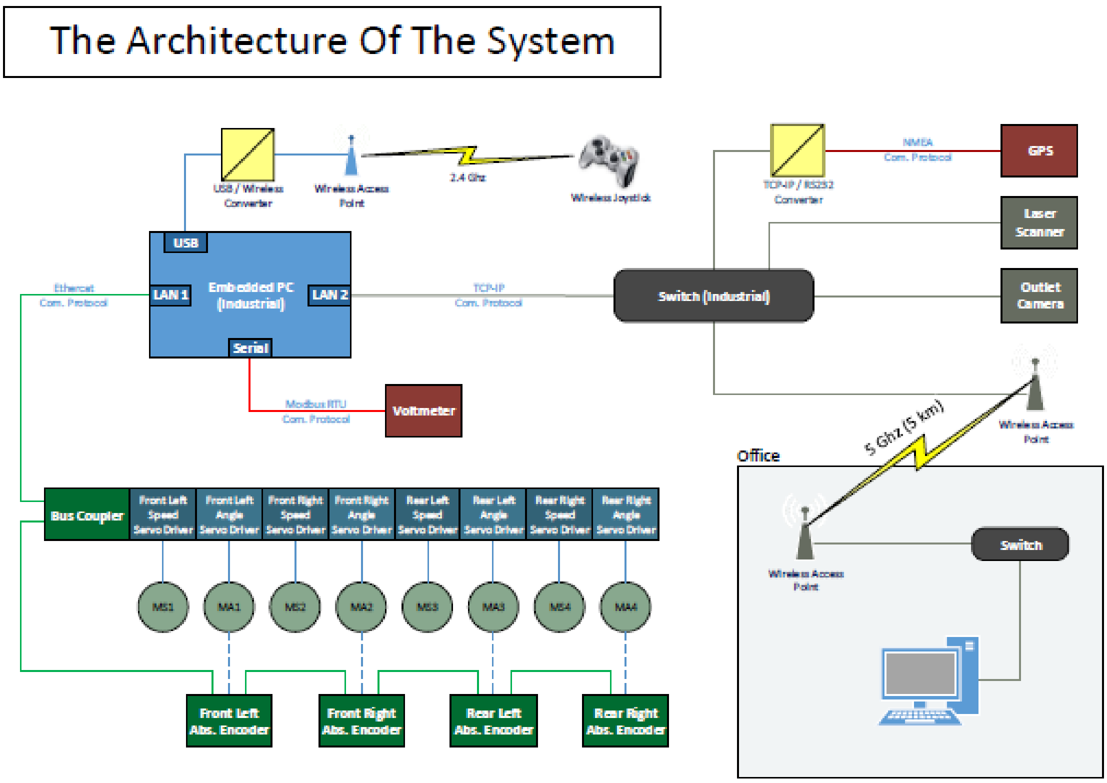

Figure 1. Concept of RoboTurk

1.1 Mechanical components

The dimensions of RoboTurk are: 1180 x 1100 mm. It has 4 independent wheels which is the simplest and cheapest traction system that a robot can have (Figure 2). Instead of having fixed axles, RoboTurk has 4 wheeled legs which are pivoted for steering. The wheels are located at the corner of a 700 * 700 mm square and the ground clearance is 700 mm. This design ensures the working flexibility under rough surface and in sloppy parcels without causing any fall over. For the transmission, each robotic leg has its own engine for the steering (enables a minimum turning radius and more accurate tracking than other steering systems) and the scrolling, which makes the system very flexible (Figure 3). The use of two engines in the same leg makes the design of the frame very simple and robust. The engines are electrical 48 Volt DC motors and they are producing 200 W of power each. Independent planetary gearboxes were used to transmit the motor power to the leg for both scrolling and steering. Each wheel is attached to the vehicle frame with a novel design. The wheels are 6.5/80-12 tubeless tyres produced for agricultural tractors.

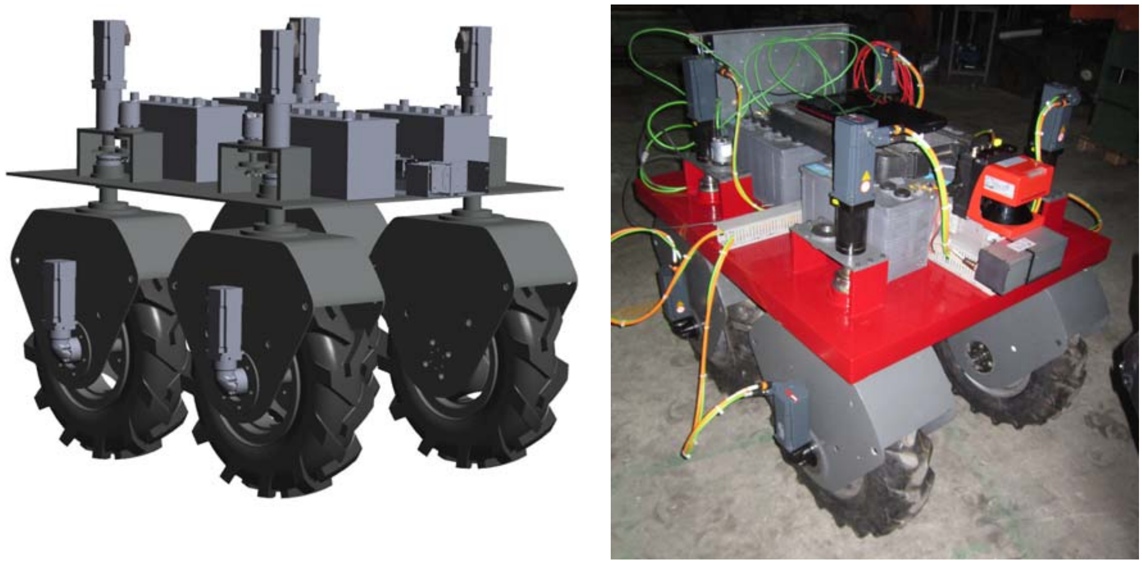

Figure 2. RoboTurk

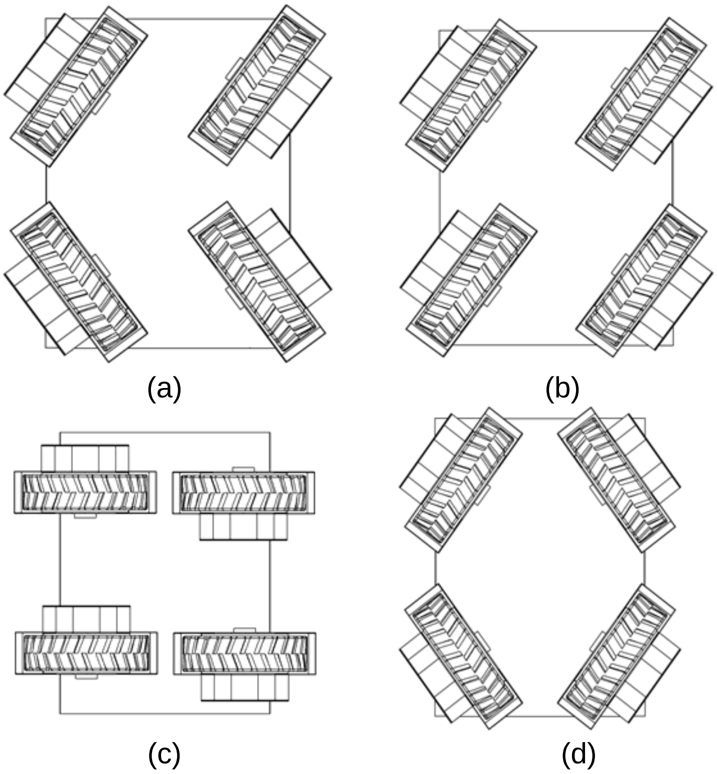

Figure 3. Steering system

1.2 Electronic components

The system architecture of the RoboTurk is given in Figure 1. All the communication is carried out via TCP/IP communication protocol which is adaptable with the ISO 11783 (ISOBUS) protocol which is being a standard protocol for agricultural equipment.

The robotic vehicle is controlled by an industrial computer; Beckhoff, CX2030-0123 CPU Module (Intel® Core™ i7 1.5 GHz, dual-core). The route plan created from SAFAR software and the commands to the central computer can be sent either through a wireless network or via Ethernet. The computer is powered with 48 Volt DC electric potential via UPS. When it is working in the fields the system consumes approximately 1000 W of power. The power supply for the system is made by four 12V batteries with a capacity of 90 Ah each. Figure 4 shows connections to and from the computer.

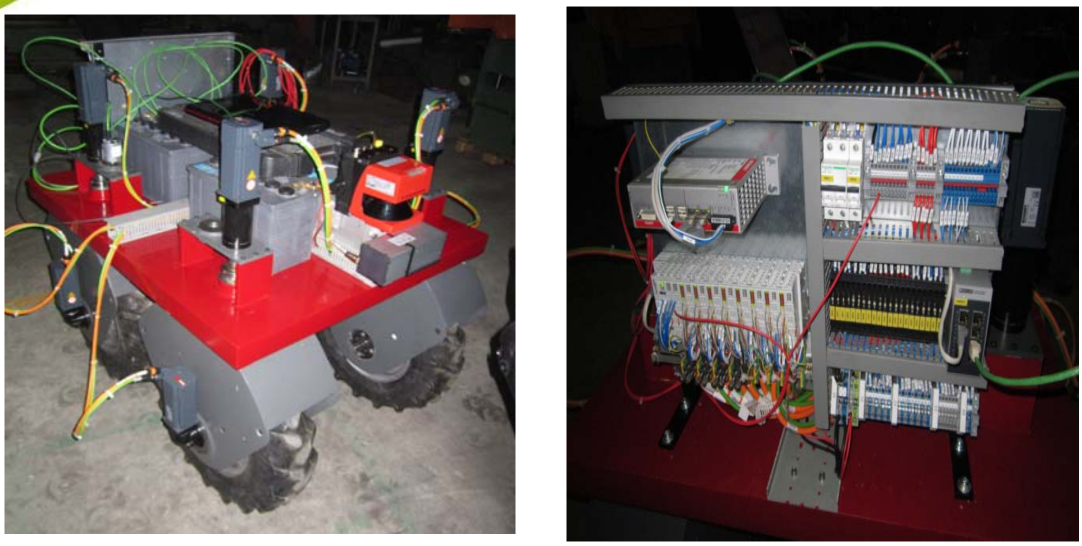

Figure 4. Electronic components of RoboTurk

1.3 Sensors

The robotic vehicle is equipped with the following auxiliary sensors: Compass, GPS, Laser Scanner, webcam, hyper spectral camera, and wireless connection antenna. The communication between the central computer and the control of each robotic leg and the SAFAR upper level software is being made through TCP/IP.

For autonomous mode, RTK GPS was installed. The technical specification is are tabulated below;

Table 1. Main features of the GPS system

. **Feature**	**Description**
GNSS Tracking	220 Chanel
	GPS L1 L2 L5 L2C
	GLONASS L1 L2
	GALILEO GIOVE-A GIOVE-B
	SBAS L1 L5
Data Management	10Hz Update (up to 50 Hz)
	CMR, CMR+, RTCM SC104 2.1, 2.3, 3.0, 3.1
	VRS, FKP, MAC Support
	NMEA Output
Communications	Integrated GPRS Modem
	Integrated UHF Modem
Accuracy	RTK H 1 cm+1ppm, V 2cm+1ppm
	PP H 0.25cm+1ppm, V 0.5cm+1ppm

The correction signal is received via a GPRS modem from CORS-TR network (Continuously Operating Reference Stations-Turkey). Static and dynamic tests revealed that the obtained accuracy is meeting the requirement of robot tracking. The frequency of data receiving is adjusted to 20 Hz which is corresponding to 5 cm at the 3.5 km/h working speed.

Laser sensors are used whenever positioning performed with great accuracy. For safety purposes, laser scanner Rod4 plus (Leuze electronic GmbH – Germany) was attached in front of the platform to carry on watch dog task by eliminating risks and accident factors in order to prevent any damage on it or its surroundings. The sensor guides the robot in a field where crop is planted in case that the GPS data transmission/correction signal will be collapsed.

High-resolution 30-bit AFS/AFM60 EtherCAT absolute encoders are installed on each leg so that the turning angel of the wheel can be feed- backed to system (Figure 5).

Figure 5. Absolute encoder

Communication between RoboTurk and office PC is another big challenge. Instead of using technology such as point to point link, 3G modem via SIM card which have several drawbacks the omni-directional wireless link can be established 360° view in 5 km range (figure 6). While the antenna modules (figure 6-a) is installed at the office, other antenna (figure 6-b) is attached to RoboTurk. In order to cover 360° view, four antenna modules (figure 6-a) is arranged side by side. The link is set up through access point which is more affective and reliable for data transmission.

(a) (b)

Figure 6. Antennas

1.4 Robotic Software

The software is divided into several sections, which are responsible for different functions (EEPPOM, Initialization, Watchdog, Safety, Blackboard, Sensing, Control, Monitoring, and Communication). The software was programmed in C#. The robotic platform has different operation modes to serve different purposes (Normal, Normal-No_Safe, Log, Long NMEA, Test, and Park). The change of mode can be done either through a command from the network, or for certain modes through the menu screen.

The RoboTurk receives route plans created with Safar software which is developed for creating and simulating route plans for agricultural robots and autonomous vehicles. SAFAR (http://www.unibots.com/SAFAR.htm) uses Google Earth and the user can grab an image from anywhere in the world, define a field by drawing its borders with a mouse, create a route plan, choose RoboTurk from its library and send the exported "*xml file" to the robot. Then, RoboTurk carries on its mission following the created route.

1.5 Initial Tests

The robotic platform was tested in laboratory conditions to monitor its performance as a whole system and as individual components. During the tests it was controlled by a wireless joystick with 100 m range. The robot has very dynamic maneuver ability. It mows forward and backward besides left and right sides without changing its head direction. Also, it can change its head direction on the center point of its current location.
In the near future, the robot will be tested in field conditions to monitor its performance and it will be controlled by a FMIS via wireless connection.

3. RESULTS and CONCLUSION

An autonomous electric vehicle (RoboTurk) was designed and developed for agricultural tasks in open field conditions, using CAD/CAE software. This small-sized vehicle can move with a very dynamic steering ability. RoboTurk can work with different kinds of sensors, such as hyper spectral camera for gathering the data from field. It can carry different implements to perform several tasks such as spraying, seeding, mulching *etc.* An important conclusion from physical experiments regarding the mechanical design was the steering system that was used. Initially, a differential steering was proposed, but that option could create several problems on the field and planted crops while turning. The four wheel steering system that was developed, makes possible a very dynamic robot movement, without causing any damage. RoboTurk is using different steering and power systems from the previous successful projects; Hortibot (Jørgensen et all., 2006) was a successful project developed by Aarhus University and has four wheel steering, but it was powered by gasoline engine. Tressos et all (2007) has developed robotic platform (ZEUS) for agricultural tasks. The other developed electric powered autonomous vehicles have differential steering. Roboturk as an electric vehicle, it eliminates Hortibot's disadvantages such as the emission of gases and it minimizes noise.
It uses the principles of auto-guided platform. Beside this principle, it can be controlled by simple Joystick. Currently the safety procedure consists of stopping the vehicle when no GPS/Correction signal is received. Furthermore, a laser scanner is used for fully stopping the vehicle in case of obstacle. In this aspect, final works would focus on evaluating the mounting several bumpers around the vehicle.

Acknowledgement

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