RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2015 Volume 23, Special Number

REMOTE DOSIMETRY MONITORING UNIT FOR HUMAN UNFRIENDLY ENVIRONMENT

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Abstract

This article deals with the design of a mobile monitoring vehicle which is intended to measure radioactivity in the human unfriendly environmental conditions. The prototype of such unmanned ground vehicle (UGV) was successfully built and tested in our controlled environment.

Key words

mobile unit, construction, environment, radioactivity

INTRODUCTION

The monitoring of environment can be very dangerous in case of failure in various kinds of industry. The most dangerous conditions are those that cannot be seen or felt. We need special equipment to measure the level of contamination and even then people cannot enter the area with a level of contamination higher than a particular limit.

Today’s technology allows us to minimize the health-risks by using the equipment which is cheaper and easier to replace than human life. The bonus is that such kind of equipment can be used for monitoring in the situations and environments where human survival would be impossible (e.g. strong air pollution level, high radioactivity level etc.).

Our goal was to design an unmanned ground vehicle (UGV) for remote dosimetry. In the broadest “dictionary” sense, an UGV is any piece of mechanized equipment that moves across the surface of the ground and serves as a means of carrying or transporting something, but explicitly does not carry a human being (1).

MAIN PLATFORM

Most of the today's UGV is based on three or four-wheel chassis. For heavy operations (high payload or difficult terrain), a twin-track design is often used. Our design is based on the CEN Matrix 5 chassis (Fig. 1). It is a 1:5 scale 4x4 chassis for terrain vehicles and belongs to the biggest in its class.

The individually suspended wheels with 21 cm diameter and 10 cm width offer approximately 7 cm ground clearance. The high-power three-phase electric motor gives enough torque and rpm for transporting all the required equipment.

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Fig. 1 *The top-, side- and front-views of the chassis*

First, we had to remove the cover and roll cage to be able to install our custom mounting plate. We had to replace the original shock springs because the payload was too heavy for original springs. Our mounting plate was installed using the original body mount set. The mounting plate was made from 3 mm thick aluminum 700 mm long and 350mm wide.

INSTALLED TECHNOLOGY

The main design concept of our UGV is based on the following items:

- Remote controlled vehicle
- Control computer
- Communication interface
- Gamma detector for radiation level measurement
- Position sensor
- Video monitoring equipment

We decided not to change the original remote control system in the first stage of the UGV development. Usable clear-view range of the original remote control is more than 1000 m on the ground, the in-building range decreases to about 100 m depending on the wall thickness and composition. Our main goal at this stage was to install all the required equipment and to prove the usability of our concept. It will be quite easy in the near future to implement RC servo interface into the installed control computer.

Control computer

The main control computer is an industrial all-in-one panel PC from NEXCOM Company (Fig. 2). The PC is equipped with 8"TFT Touch Screen, Dual-Core Intel ATOM CPU, 1GB RAM, RS-232, RS-485/RS-422, USB interfaces, Dual Gigabit Ethernet and many more. To minimize the risk of failures according to the movement vibrations, we decided to replace the standard HDD with a solid state drive (SSD).

Fig. 2 *The All-In-One Panel PC (APPC 0820)*

Technical parameters (2):

Dimensions		217.4 x 176.4 x 61.9 mm
Mass		2kg
Power consumption		Max. 60 W
I/O		GPIO: 4 x digital in / 4 x digital out COM #1: RS232 COM #2: RS232/422/485 Ethernet: 2 x RJ45 2nd display VGA port: 1 x DB15 Audio: 1 Line out; 1 x Line in; 1 x MIC-in USB: 4 x USB 2.0
Special functions		Watchdog timer: Watchdog timeout can be programmable by software from 1 second to 255 seconds and from 1 minute to 255 minutes (Tolerance 15% under room temperature 25°C) H/W status monitor: Monitoring system temperature, and voltage

We decided to include a PC with LCD only for development purposes, where it is much easier to debug and test all functions of the device. In the final stage of the development, the computer will be replaced by an industrial computer with high IP and without the monitor. This will lead to lower weight and also to lower power consumption.

Communication devices
It is possible to communicate with our device through various technologies. For in-building operations, there is a standard WiFi module available. For outside deployment, the industrial radiomodem unit is a more suitable option. We tested our UGV with a 400MHz band radiomodem RipEX-400 (Fig. 3).
RipEX provides a 24/7 reliable service for mission-critical applications like SCADA & Telemetry for Utilities, SmartGrid power networks or Transaction networks.
Every unit can serve as the central master, a repeater, a remote terminal, or all of these simultaneously. Anti-collision protocol on Radio channel allows whatever traffic: master or even multi master-slave polling and report by exception from remotes concurrently (3).

Fig. 3 *Radio modem RipEX 400 [3]*

Technical parameters (3):

Dimensions	50 H x 150 W x 118 D mm
Mass	1.1 kg
Power consumption	Slave mode: 2W Sleep mode: 0.1W Rx: up to 5W Tx: 13.8 to 41.4W
Power supply	10-30 VDC
Interfaces	Ethernet 10/100 RS232 RS232/RS485 USB Antenna
Frequency band	400-432 MHz
Channel spacing	6.25 / 12.5 / 25 / 50 kHz

Sensor equipment
As the main sensor, there was a radioactivity measurement probe installed. We used the RS04L Gamma detector (Fig. 4) from Bitt Company.

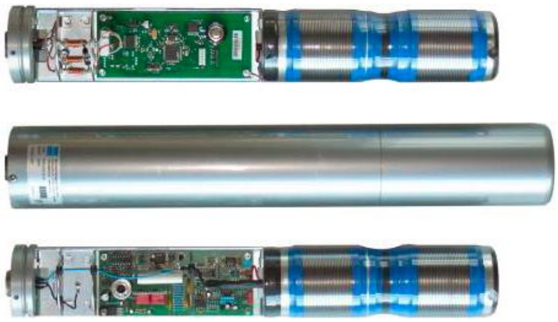

Fig. 4 *The RS04 Gamma detector inside and outside view (4)*

This type of detector is widely used in monitoring the systems near nuclear power plants. Our detector has a measuring range of 10 nSv/h ÷ 15 mSv/h which is suitable for normal operations. The RS04L can be easily replaced by RS04H which has a wider measuring range: 10 nSv/h ÷ 10 Sv/h.

Technical parameters (4):

Dimensions	Ø76 mm x 500 mm
Mass	2.5 kg
Power consumption	0.7-1.2 W

The directional dependence diagram of the RS04 is shown in Fig. 5. This feature makes the detector very suitable for dose rate monitoring without the need of source localization.

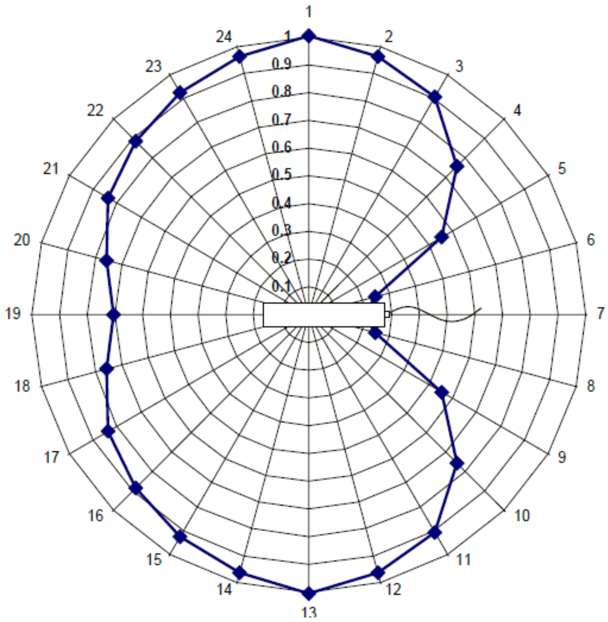

Fig. 5 *RS04 Direction dependence (4)*

When more directional characteristics are needed, lead shielding can be easily attached.
The RS04 detector can be connected through USB or RS232 interface. And RS-485 version is also available.

For outside usage, there is a GPS sensor installed (Fig. 6). The GPS sensor GM-Q782 is transmitting position data using NMEA 0183 protocol. It is connected to the computer through USB, which also provides power for sensor function.

Fig. 6 *GPS sensor QStarz GM-Q782 (5)*

Technical parameters (5):

Dimensions	64mm (L) x 57mm (W) x 16.54 mm (H)
Power consumption	200 mW
Update rate	1Hz
Position accuracy	3.0m without DGPS
DGPS	WAAS, EGNOS

MAIN ARCHITECTURE

As already described, the UGV's movement control uses the original remote control interface. Fig. 7 describes the internal and communication structure of our UGV.

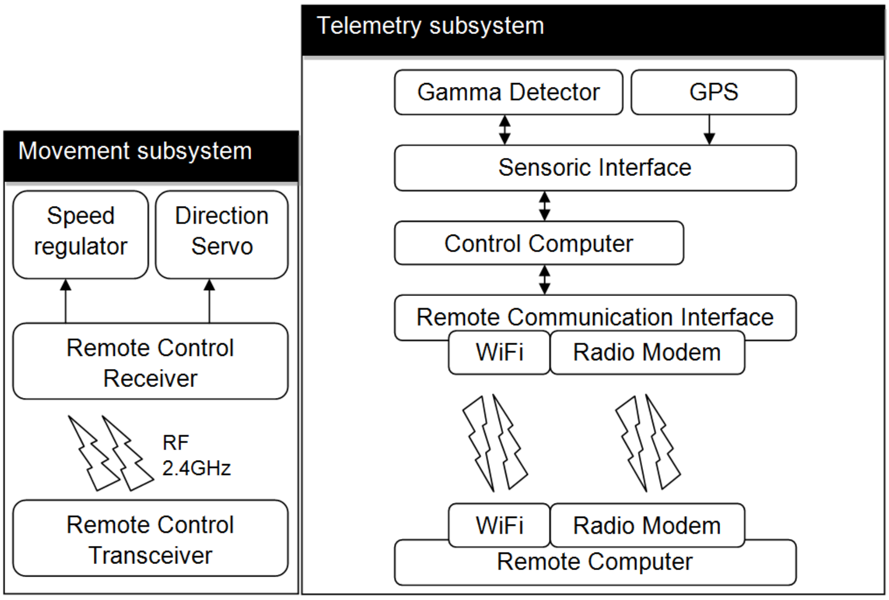

Fig. 7 *Remote unit structure*

The Remote Computer is a standard laptop with Radio Modem connected through Ethernet interface. In case of real deployment, this laptop can be replaced by a rugged industrial notebook (e.g. Panasonic Toughbook or Getac) to ensure high level of reliability.

Data Request Commands are transmitted from the Remote Computer through selected communication technology into the UGV's Control Computer. The computer sends an answer with measured data and position. The Control Computer handles the communication with all attached sensors. In our case, it is the Gamma Detector and the GPS sensor, which can be extended with various other sensors in the future.
The UGV with all installed equipment is depicted in Fig. 88. In the top left part of the picture, there is the Control Computer, and the Gamma Detector is visible in the top right part of the picture. Behind the Gamma Detector, there is a standard 35mm DIN rail with mains switch and Radio Modem.

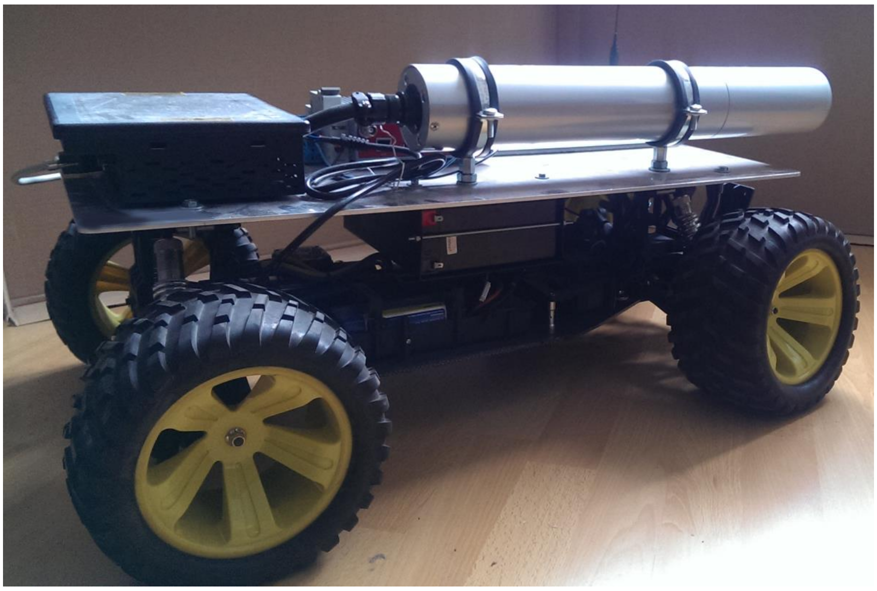

Fig. 8 *The UGV with installed equipment*

Under the mounting plate, there are two 12V/7Ah accumulators which offer enough power for 2-3 hours of operation. All our tests were performed in controlled environment with operator having a direct line of sight to the UGV. For inside operations, we tested a wireless video camera with remote controlled positioning (PTZ).

RESULTS

We designed and successfully built a prototype of UGV for remote radioactivity monitoring. The software is working, but is still under development.

DISCUSSION

The process of designing an UGV opens a lot of questions which must be answered before the main construction begins. One of the basic questions is the type of the movement subsystem. This depends mainly on the target terrain and payload weight. The next question is about the communication interface. Will the UGV be used inside of a building or outside? What is the needed active radius? What is the required data bandwidth? Very important is also the question of the sensors.

Some of these questions can be answered quite easily, some of them will lead to long discussions, but it is very important to know the answers. Otherwise, the construction costs can grow over the planned limit.

CONCLUSION

Our UGV could be used for monitoring in the areas with Gamma radiation levels dangerous to humans. By adding other kind of sensors (e.g. Gas Sensors, Pollution Sensors), there would be no problem to extend the area of deployment of our UGV.

We are planning to integrate an Inertial Positioning System with accelerometers for in-building navigation and position detection. Combining it with direct servo control from the control computer, we will be able to implement algorithms for autonomous navigation functions. This will be very useful in case of the wireless communication failure.

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