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RELIABILITY OF THE REMOTE CONTROL SYSTEM AT A UXOs DETECTION DEVICE

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ABSTRACT
Detection of unexploded ordnances (UXO at marked contaminated fields,) and clearance are phases of demining process where the involvement of human is crucial. Therefore, the minimisation of human role and his replacement with technical devices is of great importance. In an attempt for a contribution in this task, a device for UXOs detection was designed and the prototype was named as RoboDet (Robot for Detection), which is remotely controlled and equipped with sensors/metal detectors.
In this paper the remote control system (RCM), transmitter and receiver at RoboDet are elaborated. The movement of wheels and 'Moving hand' is controlled by RCM and its reliability during movement was tested.
The results of experimental measurements for the certain zones are presented in table and graphics, enabling in depth analysis.
Based on measurements in a real environment with improvised 'minefield' the reliability of RCM at RoboDet of 88%, resulted to be successful and satisfactory.
Key words: UXO, Reliability, Remote Control System, Detection Device, Clearance, Minefields

1. INTRODUCTION

In this paper is analyzed reliability of the remote control system (RMC) of the RoboDet (Robot for Detection of unexploded ordnances) [1], a device designed and constructed at a laboratory of the Faculty of Mechanical Engineering in Prishtina. This came as a result of a survey conducted on existing equipment for detection and attempt to constructing a device in the circumstances and the configuration of our country. Marking the mine fields, detection of unexploded ordnances (UXO) and clearance are phases of such a very difficult process.
Device or robot is design to detect the explosive devices through three metal detectors / sensors of metal placed in a 'moving hand' set in the body to move with two wheels doing independent movement run by two electric motors. The robot movement through the signed path is remotely controlled by the command table, as well as position of the 'moving hand'.
One of the tasks set have been to 'eliminate' the human's role during the process of explosive devices' detection and his replacement with technical devices, as the initial phase of humanitarian demining.

The reliable remote control of the prototype through electronic circuits, exactly in the certain frequency, with the transmitter electronic circuit and the receiver one is the main task of this master diploma thesis.
The fast evaluation of the technology and development of the electronic circuits, gives us different opportunities to control remotely the prototype (robot).

2. MOTIONS AND REMOTE CONTROL SYSTEM

RoboDet, fig.1 was constructed assembling elements in three main parts:

1. Skeleton or main frame, composed by two wheels, each formed by couple of chains that runs in four gears(two different couple) linked with steel sheet profile in which the rubber peace was mounted, fig.2;
2. 'Moving hand' set in which three metal detector was mounted, fig.3;
3. Control electronic system, consist of receiver and transmitter plates (each containing two part – one to control movement of wheels, other to control movement of 'moving hand' set), fig.4.

Figure 1. RoboDet

Figure 2. Skeleton

Figure3. 'Moving hand' set

Figure4. Control electronics (Receiver and Transmitter)

In the table below, table 1, is showed the basic rule under which is made the communication between the transmitter and the receiver circuit for the control of wheels' movement, while 'Moving hand' set move up/down and detection cases and its state are shown in table 2 [2].

Table 1. Control of wheels' movement

Nr of Function Code (N) W1	**Function Key**	**Decode Result**
4		End Code
10	Forward	Forward
28	Forward & Left	Forward & Left
34	Forward & Right	Forward & Right
40	Backward	Backward
46	Backward & Right	Backward & Right
52	Backward & Left	Backward & Left
58	Left	Left
64	Right	Right

Table 2. Cases of detecting

Case	Detector I	Detector II	Detector III	State
I	NO	NO	NO	Keep going
II	YES	NO	NO	Emergence stops the robot
III	NO	YES	NO	Emergence stops the robot
IV	NO	NO	YES	Emergence stops the robot

The wheels' (robot) movement is controlled by 4-channels transmitter/receiver system 1 with frequency 40MHz, while the 'Moving hand' set move up/down and turn ON/OFF is controlled by 4-channels (commands) transmitter/receiver system 2 with frequency 27MHz to avoid interference between two systems.

3. TESTING RELIABILITY OF REMOTE CONTROL SYSTEM

The testing of the remote control system has been done through experimental measurements for work of RoboDet in improvised 'minefield in the normal conditions without obstacle (object) between the transmitter unit and the robot/receiver.

The experimental measurement has been made in following steps:

- The environment around RoboDet is separated in 4 different circular zones, fig.5;
- Distance between two successive zones is 10 meter;
- In every zone 10 measurements have been conducted;
- For each measurement, are tested channels from transmitter/receiver system 1 (40 MHz) and channels from transmitter/receiver system 2 (27 MHz), table 3.

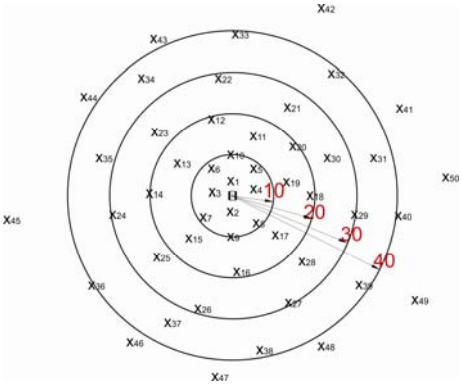

Figure 5. Zones of experimental measurements

Table is organized in two units: first is the wheel control and the second unit is 'moving hand' set. All commands that are tested in one measurement are written in the table. If certain tested command resulted successful then in the respective field is written 1, while if for any reason the tested command resulted unsuccessful then it is written 0. E.g. one unsuccessful command resulted at measurement x41 from the distance of 45 meters in the circuit of wheel control. This happened as a result of noise interfering and non-stability of receiving antenna.

Table 3. Experimental measurement data

		Wheel co.					Moving hand set					
M	D(m)	F	B	R	L	C1	Up	Down	Det. ON	Cam. ON	C2	%
X1	2	1	1	1	1	100%	1	1	1	1	100%	100%
X2	2	1	1	1	1	100%	1	1	1	1	100%	100%
X3	3	1	1	1	1	100%	1	1	1	1	100%	100%
X4	4	1	1	1	1	100%	1	1	1	1	100%	100%
X5	8	1	1	1	1	100%	1	1	1	1	100%	100%
X6	8	1	1	1	1	100%	1	1	1	1	100%	100%
X7	9	1	1	1	1	100%	1	1	1	1	100%	100%
X8	9	1	1	1	1	100%	1	1	1	1	100%	100%
X10	10	1	1	1	1	100%	1	1	1	1	100%	100%
X9	10	1	1	1	1	100%	1	1	1	1	100%	100%
X19	13	1	1	1	1	100%	1	1	1	1	100%	100%
X17	14	1	1	1	1	100%	1	1	1	1	100%	100%
X11	15	1	1	1	1	100%	1	1	1	1	100%	100%
X15	15	1	1	1	1	100%	1	1	1	1	100%	100%
X13	16	1	1	1	1	100%	1	1	1	1	100%	100%
X16	18	1	1	1	1	100%	1	1	1	1	100%	100%
X18	18	1	1	1	1	100%	1	1	1	1	100%	100%
X12	19	1	1	1	1	100%	1	1	1	1	100%	100%
X20	19	1	1	1	1	100%	1	1	1	1	100%	100%
X14	20	1	1	1	1	100%	1	1	1	1	100%	100%
X28	23	1	1	1	1	100%	1	1	1	1	100%	100%
X25	24	1	1	1	1	100%	1	1	1	1	100%	100%
X21	25	1	1	1	1	100%	1	1	1	1	100%	100%
X23	25	1	1	1	1	100%	1	1	1	1	100%	100%
X30	25	1	1	1	1	100%	1	1	1	1	100%	100%
X26	27	1	1	1	1	100%	1	1	1	1	100%	100%
X22	28	1	1	1	1	100%	1	1	1	1	100%	100%
X24	29	1	1	1	1	100%	1	1	1	1	100%	100%
X27	29	1	1	1	1	100%	1	1	1	1	100%	100%
X29	30	1	1	1	1	100%	1	1	1	1	100%	100%
X35	34	1	1	1	1	100%	1	1	1	1	100%	100%
X31	35	1	1	1	1	100%	1	1	1	0	75%	88%
X37	35	1	1	1	1	100%	1	1	1	1	100%	100%
X34	36	1	1	1	1	100%	1	1	1	1	100%	100%
X32	37	1	1	1	1	100%	1	0	1	0	50%	75%
X39	37	1	1	1	1	100%	1	1	1	1	100%	100%
X33	38	1	1	1	1	100%	1	1	1	1	100%	100%
X38	38	1	1	1	1	100%	1	1	1	1	100%	100%
X36	40	1	1	1	1	100%	1	1	1	1	100%	100%
X40	40	1	1	1	1	100%	1	1	1	1	100%	100%
X44	43	1	1	0	0	50%	1	0	0	0	25%	38%
X48	43	1	1	1	1	100%	1	0	1	0	50%	75%
X46	44	1	1	1	1	100%	1	0	0	0	25%	63%
X41	45	0	1	1	1	75%	0	0	0	0	0%	38%
X47	45	1	1	1	1	100%	0	0	0	0	0%	50%
X43	48	1	1	1	1	100%	0	0	0	0	0%	50%
X49	49	1	1	1	1	100%	0	0	0	0	0%	50%
X42	50	1	1	0	1	75%	0	0	0	0	0%	38%
X45	50	1	0	0	1	50%	0	0	0	0	0%	25%
X50	50	1	0	0	1	50%	0	0	0	0	0%	25%
						96%					81%	88%

4. CONCLUSIONS

Based on experimental measurements from the table 3 and the graphics shown in fig. 6, it can be noticed that:

- ✓ The average reliability of the wheels control system for the robot (in percentage) of all measurements is about 96%, fig. 6a.;
- ✓ The average reliability of 'moving hand' set control system in function of distance is about 81%, fig. 6b.;
- ✓ Total average reliability of controlling the RoboDet remotely for all measurements depending on distance is approximately 88%, fig. 6c.

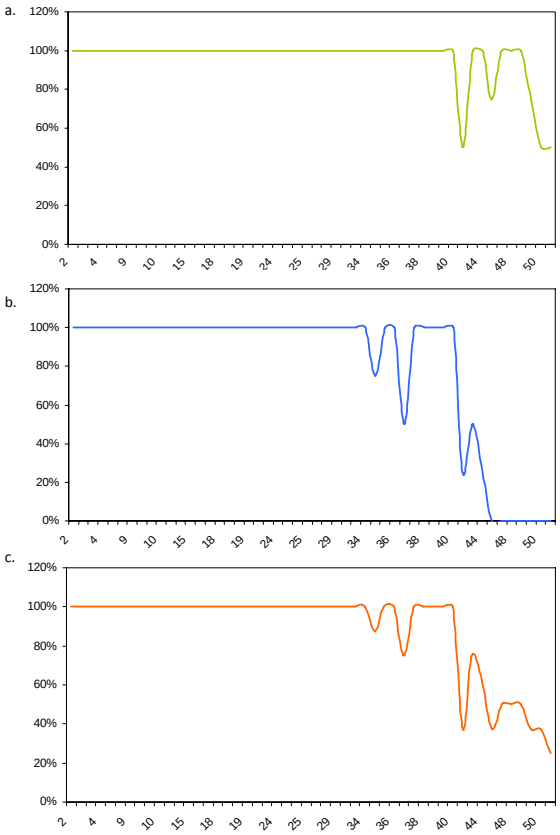

Figure 6. Reliability of remoter control system

Therefore it can be concluded that:

- RoboDet designed and manufactured at the Faculty of Mechanical Engineering laboratory in Prishtina fulfills driving, detection and remote control criteria.
- Its testing in real environment with improvised 'minefield' resulted successful and satisfactory.
- Reliability of remote control system (RMC) of approximately 88% for Robodet gives enough safety for users decreasing danger and the role of human.
- It is expected that reliability be satisfactory for even larges distances if used powerful and long distance transmitter/receiver systems.
- RoboDet can be considered as a good platform for further advanced driving and control researches and developments.
- This robot can be added a microcontroller and be programmed with an appropriate algorithm, in order to have the opportunity of acting as autonomous or semi-autonomous.

5. REFERENCES

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