The 7th IARP Workshop

Robotics and Mechanical assistance in Humanitarian De-mining and Similar risky interventions

HUDEM'2008

28-30 March, 2008

The American University in Cairo (AUC), Cairo

EGYPT

ABSTRACTS

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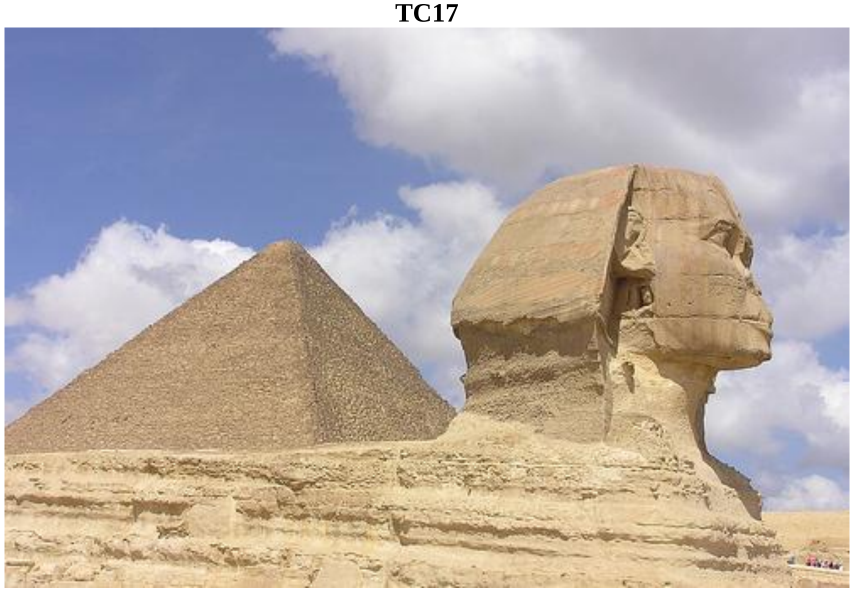

Dear Colleagues,

The International Advanced Robotics Project was established by the Heads of State of G7 in 1982, recognizing the strategic role of robotics technologies in furthering economic and social development. A final report on this project was presented in the Tokyo Economic Summit in 1986. The **International Advanced Robotics Programme** was also established in 1986 to pursue the intent of the 1982 Economic Summit and, although it no longer reports to the Heads of State of the G7, it remains a government based activity, open to all countries. The objective of IARP is:

> "To foster international cooperation toward the development of advanced robotic systems capable of eliminating or minimizing human exposure to difficult activities in harsh, demanding, dangerous conditions or environments".

Since its establishment, IARP has fostered and catalysed international cooperation in "hot research topics", as well as in application domains that encompass or use robotics and intelligent machines. It has also paved the way for the introduction of new promising research directions
In 1996, IARP generated a report assessing the status and the future impact of Robotics Research Technologies in practical applications. Industrial Robots were a typical example, integrating many technologies. At the end of 1995, the world total of industrial robots, primarily in manufacturing industries, was approximately 700,000 with a yearly growth rate averaging 30%.
Ever since, a new category of robots has emerged, namely service and intervention robots. Their number has outpaced industrial robots and they became an important market segment, with applications including:

- Materials handling and transportation, construction, sewer inspection and repair, etc.
- Field-based applications such as mining, forestry, agriculture, underwater and space.
- Public-oriented areas ranging from domestic and professional cleaning, handling dangerous substances, hotel and hospital catering, assistance to the disabled and the aging.
- Network based remote operations.
- Healthcare, surgical, and medical intervention.

The IARP workshops, with limited attendance, by invitation only, can be domain oriented, or directed to a specific scientific, engineering, or technical subject. Their aim is to assess particular problems, foster institutional actions and international cooperation, and help codify knowledge in important technical areas of Advanced Robotics.
We sincerely hope that Your participation to this 7th workshop HUDEM'2008 will support our efforts. In particular, we are convinced that the International community focusing on Humanitarian de-mining (www.itep.ws) will appreciate your active participation. Six successful IARP WS preceded this one: Toulouse (France), Harare (Zimbabwe), Vienna (Austria), Pristhina (Kosovo), Brussels (Belgium), Tokyo (Japan).
The ambassador of Egypt opened the last workshop with a description of the Egyptian Problem: we then decided to organise our 7th WS in Cairo.
Hoping the new technologies will serve the Convention of Ottawa.

Professor Yvan Baudoin
Chairman of the IARP Working Group HUDEM

Professor Maki Habib
Chairman of this 7th IARP Workshop

IARP Member and Observer Countries

Australia	*Hugh Durrant-Whyte*
Austria	*P. Kopacek*
Belgium	*Y. Baudoin*
Brasil	*Liu Hsu*
Canada	*E. Dupuis*
China, P.R	*X.Dai*
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Robotics solutions properly sized with suitable modularized mechanized structure and well adapted to local conditions of dangerous unstructured areas can greatly improve the safety of personnel as well as the work efficiency, productivity and flexibility. Solving this problem presents challenges in robotic mechanics and mobility, sensors and sensor fusion, autonomous or semi autonomous navigation and machine intelligence.
The workshop will review and discuss the available technologies, their limitations, their adaptability to different environmental natural or artificial calamities (humanitarian de-mining obviously but also Earthquake, fire, chemical pollution, natural disaster, CBRN-E threat, etc) and discusses the development efforts to automate tasks related to de-mining / detection / interventions processes wherever possible through the use of Robotics Systems and other technologies.

Again many thanks to the authors and co-authors of this 7th IARP Workshop.

7th IARP WS HUDEM'2008

PROGRAM

SESSIONS F 1-3 and Round Table: 28 March 2008, Friday

08.00H REGISTRATION		
KEYNOTE SESSION **8:45 – 9:30 H** Mobile Robotic Systems Facing the Humanitarian Demining Problem: State of the Art (SOTA) December 2007 ITEP 3.1.4 Task **Prof. Yvan Baudoin (RMA)** ***Chairman:*** ***Prof. Maki K. Habib (AUC)***		
SESSION F1. MOBILE ROBOTICS SYSTEMS - I **Chairman :** **Prof Y. Baudoin (RMA)**		
09.30-10.00H	Mechanical Design of a New Locomotion Concept for Humanitarian De-mining	Prof. Dr. Dr.h.c.mult. Peter Kopacek Lukas Silberbauer Institute of Handling Devices and Robotics Vienna University of Technology Favoritenstraße 9-11 1040 Vienna, Austria
10.00-10.20H	Development of a semi-autonomous De-mining vehicle	Daniela Doroftei, Yvan Baudoin Royal Military School (RMS) Department of Mechanical Engineering (MSTA) Av. de la Renaissance 30, 1000 Brussels, Belgium
10:20 – 10:40 COFFEE BREAK		
SESSION F2. MOBILE ROBOTICS SYSTEMS - II **Chairmen:** **Prof P. Kopacek (Vienna University of Technology) and Edwardo F. Fukushima (Tokyo Institute of technology)**		
10.40-11.00H	Remote Operation of the Mini MineWolf in High-Threat Mine Environments	Christoph Frehsee Director Products and Services MineWolf Systems AG Seedammstrasse 3 8808 Pfäffikon SZ Switzerland

11.00-11.20H	De-mining techniques of improvised explosive materials by the usage of mobile robots.	Arbnor Pajaziti, Jakup Berisha, Xhevahir Bajrami Faculty of Mechanical Engineering, University of Prishtina Kosova Arbnesh Ajvazi Improvised Explosive Device Disposal Unit, Kosovo Police Service Kosova
11.20-11.40H	Humanitarian Demining Robot Gryphon - an Objective Evaluation	Marc Freese, Edwardo F. Fukushima and Shigeo Hirose Tokyo Institute of Technology
11.40-12.00H	Agricultural derived tools for ground processing in humanitarian de-mining operations – set up of testing facility in Jordan	Emanuela Elisa Cepolina (1) & Bassam Snobar (2), (1) PMARlab, Department of Mechanics and Machine Design (DIMEC), University of Genova, Italy (2) Professor at the Department of Horticulture and Crop Science, Faculty of Agriculture, University of Jordan, Amman, Jordan.
12:00 – 13:40 LUNCH		
SESSION F3: SENSOR SYSTEMS **Chairmen:** **Ptof. H. Itozaki (Osaka University) and Dr. S.Baglio (Univ. degli Studi di Catania)**		
13.40-14.00H	Nuclear Quadrupole Resonance for explosive detection	Hideo Itozaki and Go Ota Osaka University Graduate School of Science Engineering 1-3 Machikaneyama Toyonaka, Osaka 560-8531,Japan
14.00-14.20H	Exploitation of nonlinear dynamics in ferromagnetic and ferroelectric materials for novel high performances B-field and E-field sensors	B. Andò, S. Baglio, N. Savalli, C. Trigona Facoltà di Ingegneria, Univ. degli Studi di Catania, DIEES Viale A. Doria 6, 95125 Catania, Italy. V. In, A. R. Bulsara Space and Naval Warfare Systems Center 49590 Lassing Road A341, San Diego, CA 92152-5001, USA
14.20-14.40H	A Complementary Multi-sensory Method for Landmine Detection	Snaider Carrillo(1), Carlos Santacruz(1), Diego Botero(1), Alejandro Forero(1), Carlos Parra(1) and Michel Devy(2) (1)Pontificia Universidad Javeriana, Carrera 7ª No. 40 – 62. Bogotá, Colombia (2) Laboratoire d'Analyse et d'Architecture des Systèmes (LAAS-CNRS). 7, Avenue du Colonel Roche, 31077 Toulouse Cedex 4, France
14.40-15.00H	Fuzzy Template Based Automatic Landmine Detection from GPR Data	Zakarya Zyada1, Takayuki Matsuno2 and Toshio Fukuda3

		1 Mechanical Eng. Dept., Tanta Univ., Tanta, Egypt; 2 Dept. of Intelligent Systems Design Eng., Toyama Prefectural Univ., Toyama, Japan; **3** Micro-Nano System Eng. Dept., Nagoya Univ., Nagoya Japan
15:00 – 15.20H	Landmine detection using integration of GPR and Magnetic survey	M. A. Atya, I. El-Hemaly, A. Khozym, A. El-Emam, G. El-Qady, M. Soliman and M. Abd Alla National Research Institute of Astronomy and Geophysics, Cairo, Egypt.
15.20-16:00 ROUND TABLE on ROBOTS and SENSORS for Humanitarian De-mining		
16:00 – 16:20 COFFEE BREAK – End of F Sessions.		

SESSIONS Keynote, T1-T4, and Workshop Dinner: 29 March 2008, Saturday

KEYNOTE SESSION ***8:45 – 9:30 H*** Humanitarian Demining and the Challenge of Technology **Prof. Maki Habib** The American university of Cairo ***Chairman:*** ***Prof. Y.Baudoin (RMA)***		
SESSION T1. DATA PROCESSING, CONTROL and SIMULATION - I **Chairman:** **Prof Maki Habib (AUC) and Dr. Munsang Kim (KIST)**		
09.30-09.50H	Legged robot - Animal cooperation to trace smell gradients in minefields	Thrishantha Nanayakkara[1], Tharindu Amal Dissanayaka[2], Lasitha Piyathilaka[3] [1] School of Engineering and Applied Science, Harvard University, USA, Email: thrish@deas.harhard.edu [2] Department of Mechanical Engineering, University of Moratuwa, Sri Lanka [3] Department of Electical Engineering, University of

		Moratuwa, Sri Lanka
09.50-10.10H	Data Association for Robot Localization in Satellite Images	Sid Ahmed Berrabah, Yvan Baudoin Mechanical Department, Royal Military School, Avenue de la Renaissance 30, 1000 Brussels, Belgium
10.20 – 10.40 COFFEE BREAK		
SESSION T2. DATA PROCESSING, CONTROL and SIMULATION - II **Chairmen:** **Prof. Janusz Bedkowski (PIAP) and Dr. Ayman Abbas (BUE)**		
10.40-11.00H	Cognitive Theory – Based Approach for Inspection using Multi Mobile Robot Control.	*Janusz Bedkowski, Andrzej Maslowski* Research Institute for Automation and Measurements PIAP, Warsaw, Poland
11.00-11.20H	Framework for Creation of the Simulators for Inspection Robotic Systems	Janusz Bedkowski, Grzegorz Kowalski, Andrzej Masłowski Research Institute for Automation and Measurements PIAP, Warsaw, Poland
11.20-11.40H	A Fuzzy Approach for the Control of Autonomous Vehicles Operating in Hazardous Terrain Environments	Dr Ayman Abbas British University in Egypt
11.40-12.00H	Virtual Training System for Teleoperation of ROBHAZ-DT2	Dongseok Ryu, Sungchul Kang, Munsang Kim Korea Institute of Science and Technology Center for Intelligent Robotics
12:00 – 13:30 LUNCH		
SESSION T3 : RISKY INTERVENTIONS-ENVIRONMENTAL SURVEILLANCE **Chairmen:** **Prof G. Muscato (DIEES) and Prof. V. G. Gradetsky (Russian Academy of Sciences)**		
13.30-13.50H	Heterogeneous robot cooperation for interventions in risky environments	C. Bruno, D. Longo, D. Melita, G. Muscato, S. Sessa, G. Spampinato DIEES Università degli Studi di Catania Viale A. Doria 6 Catania, Italy
13.50-14.10H	HIL tuning of UAV for exploration of risky environments	G. Astuti, D. Longo, D. Melita, G. Muscato, A. Orlando DIEES Università degli Studi di Catania Viale A. Doria 6 Catania, Italy
14.10-14.30H	AMARANTA: Modular Platform for a Mine Hunting Robot	Snaider Carrillo(1), Carlos Santacruz(1), Diego Botero(1), Carlos Parra(1) , Alvaro Hilarión(1), Martha Manrique(1), Camilo Otalora(1) and Michel Devy(2) (1)Pontificia Universidad Javeriana, Carrera 7ª No. 40 – 62. Bogotá, Colombia

		(2) Laboratoire d'Analyse et d'Architecture des Systèmes (LAAS-CNRS). 7, Avenue du Colonel Roche, 31077 Toulouse Cedex 4, France
14.30-14.50H	Demining in Shallow Inland Water Areas	Viktor Kálmán PhD student, Miklós Vogel researcher, dr. László Vajta associate professor Budapest University of Technology and Economics Department of Control Engineering and Information Technology
14.50-15.10H	Robotic Assistance in Extreme Conditions	Professor V. G. Gradetsky The Institute for Problems in Mechanics of Russian Academy of Sciences
15.10-15.30H	Model-Based Soil Parameter Identification For Wheel-Terrain Interaction Dynamics	Suksun Hutangkabodee, Yahya H Zweiri, Lakmal D Seneviratne, Kaspar Althoefer Department of Mechanical Engineering, King's College London, Strand, London WC2R 2LS, UK
15.30-15.50H	Robotised Combine to demining of mine fields	Marin Midilev 40-A-10, Badema str 6300 Haskovo Bulgaria
CONCLUSIONS : IARP WS'HUDEM'2009 OBJECTIVES – ITEP CONTRIBUTION **HUDEM' 2008 Workshop Dinner**		

The 7th IARP WS HUDEM'2008

LIST OF PARTICIPANTS

11	Cognitive Theory – Based Approach for Inspection using Multi Mobile Robot Control.	*Janusz Bedkowski, Andrzej Maslowski* Research Institute for Automation and Measurements PIAP, Warsaw, Poland	amaslowski@piap.pl, jbedkowski@piap.pl
12	Framework for Creation of the Simulators for Inspection Robotic Systems	Janusz Bedkowski, Grzegorz Kowalski, Andrzej Masłowski Research Institute for Automation and Measurements PIAP, Warsaw, Poland	amaslowski@piap.pl, jbedkowski@piap.pl, gkowalski@piap.pl,

13	Legged robot - Animal cooperation to trace smell gradients in minefields	Thrishantha Nanayakkara[1], R. H. Lakshita Ranasingha[2], and D. Madura Rajapaksha[2] [1] School of Engineering and Applied Science [2]Harvard University, USA Department of Mechanical Engineering University of Moratuwa, Sri Lanka	thrish@deas.harvard.edu
14	Remote Operation of the Mini MineWolf in High-Threat Mine Environments	Christoph Frehsee Director Products and Services MineWolf Systems AG Seedammstrasse 3 8808 Pfäffikon SZ Switzerland	C.Frehsee@minewolf.com
15	Nuclear Quadrupole Resonance for explosive detection	Hideo Itozaki and Go Ota Osaka University Graduate School of Science Engineering 1-3 Machikaneyama Toyonaka, Osaka 560-8531,Japan	Itozaki@ee.es.osaka-u.ac.jp
16	Exploitation of nonlinear dynamics in ferromagnetic and ferroelectric materials for novel high performances B-field and E-field sensors	B. Andò, S. Baglio, N. Savalli, C. Trigona Facoltà di Ingegneria, Univ. degli Studi di Catania, DIEES Viale A. Doria 6, 95125 Catania, Italy. V. In, A. R. Bulsara Space and Naval Warfare Systems Center 49590 Lassing Road A341, San Diego, CA 92152-5001, USA	salvatore.baglio@diees.unict.it
17	Heterogeneous robot cooperation for interventions in risky environments	C. Bruno, D. Longo, D. Melita, G. Muscato, S. Sessa, G. Spampinato DIEES Università degli Studi di Catania Viale A. Doria 6 Catania, Italy	gmuscato@diees.unict.it
18	HIL tuning of UAV for	G. Astuti, D. Longo,	gmuscato@diees.unict.it

	exploration of risky environments	D. Melita, G. Muscato, A. Orlando DIEES Università degli Studi di Catania Viale A. Doria 6 Catania, Italy	
19	De-mining techniques of improvised explosive materials by the usage of mobile robots.	Arbnor Pajaziti, Jakup Berisha, Xhevahir Bajrami Faculty of Mechanical Engineering, University of Prishtina Kosova Arbnesh Ajvazi Improvised Explosive Device Disposal Unit, Kosovo Police Service Kosova	apajazit@uni-pr.edu ; jakup.berisha@gmail.com ; xhevahirbajrami070@hotmail.com arbnesh.ajvazi@kosovopolice.com
20	Fuzzy Template Based Automatic Landmine Detection from GPR Data	Zakarya Zyada[1], Takayuki Matsuno[2] and Toshio Fukuda[3] [1] Mechanical Eng. Dept., Tanta Univ., Tanta, Egypt; [2] Dept. of Intelligent Systems Design Eng., Toyama Prefectural Univ., Toyama, Japan; [3] Micro-Nano System Eng. Dept., Nagoya Univ., Nagoya, Japan	zzyada@yahoo.com
21	Humanitarian Demining and the Challenge of Technology	Maki K. habib The American University in Cairo, Egypt	maki@aucegypt.edu
22	Humanitarian Demining Robot Gryphon - an Objective Evaluation	Marc Freese, Edwardo F. Fukushima and Shigeo Hirose Tokyo Institute of Technology	marc@sms.titech.ac.jp fukusima@mes.titech.ac.jp
23	Agricultural derived tools for ground processing in humanitarian de-mining operations – set up of testing facility in Jordan	Emanuela Elisa Cepolina (1) & Bassam Snobar (2), (1) PMARlab, Department of Mechanics and Machine Design (DIMEC), University of Genova, Italy (2) Professor at the	emacepo@dimec.unige.it Snobar@ju.edu.jo

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24	AMARANTA: Modular Platform for a Mine Hunting Robot	Snaider Carrillo(1), Carlos Santacruz(1), Diego Botero(1), Carlos Parra(1) , Alvaro Hilarión(1), Martha Manrique(1), Camilo Otalora(1) and Michel Devy(2) (1)Pontificia Universidad Javeriana, Carrera 7ª No. 40 – 62. Bogotá, Colombia (2) Laboratoire d'Analyse et d'Architecture des Systèmes (LAAS-CNRS). 7, Avenue du Colonel Roche, 31077 Toulouse Cedex 4, France	carlos.parra@javeriana.edu.co alejandro.forero@javeriana.edu.co michel@laas.fr
25	Data Association for Robot Localization in Satellite Images	Sid Ahmed Berrabah, Yvan Baudoin Mechanical Department, Royal Military School, Avenue de la Renaissance 30, 1000 Brussels, Belgium	sidahmed.berrabah@rma.ac.be
26	A Fuzzy Approach for the Control of Autonomous Vehicles Operating in Hazardous Terrain Environments	Dr Ayman Abbas British University in Egypt	Aabbas@bue.edu.eg
27	A COMPLEMENTARY MULTISENSORY METHOD FOR LANDMINE DETECTION	Snaider Carrillo(1), Carlos Santacruz(1), Diego Botero(1), Alejandro Forero(1), Carlos Parra(1) and Michel Devy(2) (1)Pontificia Universidad Javeriana, Carrera 7ª No. 40 – 62. Bogotá, Colombia (2) Laboratoire d'Analyse et d'Architecture des Systèmes (LAAS-CNRS). 7, Avenue du Colonel	carlos.parra@javeriana.edu.co alejandro.forero@javeriana.edu.co michel@laas.fr

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28	Mechanical Design of a New Locomotion Concept for Humanitarian Demining	Dr.h.c.mult. Peter Kopacek Lukas Silberbauer Institute of Handling Devices and Robotics Vienna University of Technology Favoritenstraße 9-11 1040 Vienna, Austria	kopacek@ihrt.tuwien.ac.at lukas.silberbauer@austrobotics.at
29	Robotised Combine to demining of mine fields	Marin Midilev 40-A-10, Badema str 6300 Haskovo Bulgaria	midilev@abv.bg
30	Mobile Robotic Systems Facing the Humanitarian Demining Problem State of the Art (SOTA) December 2007 ITEP 3.1.4 Task	Yvan Baudoin, et Al Royal Military Academy (RMA) 30 Av de la Renaissance B 1000 Brussels, Belgium	Yvan.baudoin@rma.ac.be
33	Demining in Shallow Inland Water Areas	Viktor Kálmán PhD student, Miklós Vogel researcher, dr. László Vajta associate professor Budapest University of Technology and Economics Department of Control Engineering and Information Technology	kalman@iit.bme.hu vogel@iit.bme.hu *vajta@iit.bme.hu*
34	Robotic Assistance in Extreme Conditions	Professor V. G. Gradetsky The Institute for Problems in Mechanics of Russian Academy of Sciences	gradet@mail.ru
35	Virtual Training System for Teleoperation of ROBHAZ-DT2	Dongseok Ryu, Sungchul Kang, Munsang Kim Korea Institute of Science and	munsang@kist.re.kr

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36	Landmine detection using integration of GPR and Magnetic survey	M. A. Atya, I. El-Hemaly, A. Khozym, A. El-Emam, G. El-Qady, M. Soliman and M. Abd Alla National Research Institute of Astronomy and Geophysics, Cairo, Egypt	magdyatya@yahoo.com *gadosan@nriag.sci.eg*
37	Model-Based Soil Parameter Identification For Wheel-Terrain Interaction Dynamics	Suksun Hutangkabodee, Yahya H Zweiri, Lakmal D Seneviratne, Kaspar Althoefer	suksun.hutangkabodee@kcl.ac.uk; yahya.zweiri@kcl.ac.uk; lakmal.seneviratne@kcl.ac.uk; k.althoefer@kcl.ac.uk

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Mobile Robotic Systems Facing the Humanitarian Demining Problem: State of the Art (SOTA) December 2007 ITEP 3.1.4 Task

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The mines have been used for the first time during the American Civil War in the United States (1861-1865). Antitank mines were later ameliorated and laid on the battlefields of the First World War: the mine-clearing operations didn't pose major problems with those visible or easy-to-detect ATK-mines, reason why Anti-personnel mines have been conceived and systematically used on the ATK minefields during the Second World War: such mines prevented the enemy from easy de-mining of the defence system. But the anti-personnel mines are today more and more used as offensive weapons and for sowing the terror among the civilian population of a country affected by guerrilla war: the marking of the minefield does no more exist and the anti-personnel mines, often buried in the ground, remain active after the war: about 60 millions AP-mines infest today more than 70 countries all over the world, two-third of them in Africa and South-East Asia…AP mines and Unexploded devices of the Second World War still exist in all the countries of Europe and North-Africa

Due to the central geographical location between Africa, Asia and Europe, Egypt was a location for many battles. During the Second World War, the most known El-Alameen battle, Western Desert, (Fig.1) was between the British and German troops. As a result of this fighting, a numerous number of anti-tanks and anti-personnel mines have been left. The total number of mines (19,711 Million mines) that was buried in the Egyptian land is considered to be about 21% of the total number of mines that buried in the whole world . The presence of such active mines caused many problems to Egypt

Fig.1. Location map for landmines distributions in Egypt

In 1994, the United Nations Mine Action Service or UNMAS was founded, with as objectives the mine awareness and risk reduction education, the minefield survey, mapping, marking and clearance, the assistance to victims, the advocacy to support a total ban on AP-mines, and, in 1999, the treaty of Ottawa (the Convention on the Prohibition of the use, stockpiling, production and transfer of AP-mines and their destruction) entered into force. The European Commission launched several programmes to encourage the Scientific Community to develop research activities allowing to improve the de-mining tools, according to the next priorities:

Priority 1	the development of reliable sensors allowing the detection of minefields and , on those minefields, the detection of the mines (or similar explosive devices)
Priority 2	the development of data processing algorithms confirming the detection and leading to the identification of the parameters needed for the next actions
Priority 3	the development of fast removal techniques or neutralization techniques
Priority 4	the development of the mechanical assistance

The development of a Robotics System not only depends on the technical aspects and modular components allowing the correct design of the remote controlled platform(s): the application related constraints have also to be carefully analysed in order to achieve the success of the whole system.
The constraints related to the Humanitarian De-mining, and more generally to outdoor applications, may be summarised as follows: a high level of protection against the environmental conditions (dust, humidity, temperature, etc.), protection and resistance against vibration and mechanical shocks, long and continuous operation time between battery charging/changing or refuelling, wireless communication range depending on the terrain and minefield location, low cost, affordable prices by use of off-the-shelf components (typical constraint for HUDEM due to the lack of a real commercial market), high reliability, fail-safeness, easy maintenance, easy to use, application of matured technology.
In this paper, some of the most relevant aspects of both technical and environmental aspects are underlined.

Mechanical Design of a New Locomotion Concept for Humanitarian Demining

o.Univ.Prof. Dr. Dr.h.c.mult. Peter Kopacek
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Landmines continue to be a burden for 78 countries and a challenge for mobile autonomous robots used for detecting and clearing them. Although robots are less error prone, not affected by heath or other environmental conditions and much more accurate than their human colleagues they still suffer from inferior locomotion systems in rough terrain. The most important requirements for a demining robot’s propulsion are reliability, maneuverability, obstacle surmounting capability and low ground pressure. In order to evaluate new locomotion alternatives a virtual obstacle course has been build using simulation software. The course contains rocks, tree logs, concrete plates, steep slopes and stairs. Inspired by Mars Rovers and other articulated vehicles a creative process started to
simplify their locomotion principle while maintaining its advantages. After a promising solution was found it has been optimized in an iterative approach.

The paper will describe a design process involving a low cost method for rapidly building robot prototypes using commercial off-the-shelf (COTS) components. Considerations and calculations for the selection of parts are outlined. A key element of the resulting vehicle is its innovative chassis frame geometry. As with cars a chassis frame’s quality is of utmost importance for the overall quality of the vehicle. In order to reduce effort and costs commercial aluminum profiles are used wherever possible, an approach which is state of the art in plant engineering and construction. Furthermore mechanical design challenges in suspension dimensioning, motor selection and steering are approached. The final vehicle is evaluated by building a one-to-one prototype.

Development of a semi-autonomous De-mining vehicle

Daniela Doroftei, Yvan Baudoin

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Humanitarian de-mining is still a highly labor-intensive and high-risk operation. Advanced sensors and mechanical aids can significantly reduce the de-mining time. In this context, it is the aim to develop a humanitarian de-mining mobile robot (figure 1) which is able to scan semi-automatically a minefield. This paper discusses the development of a control scheme for such a semi-autonomous mobile robot for humanitarian demining. This process requires the careful consideration and integration of multiple aspects: sensors and sensor data fusion, design of a control and software architecture, design of a path planning algorithm and robot control.

Index Terms—Semi-autonomous robotics, de-mining robots, mobile robot navigation, robot control and software architectures

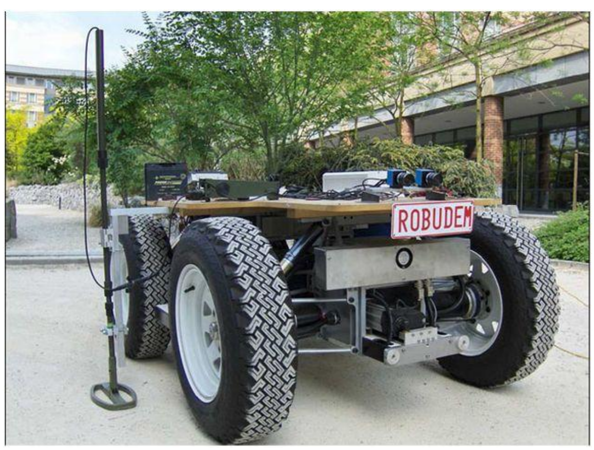

Figure 1: The RobuDem robot

Remote Operation of the Mini MineWolf in High-Threat Mine Environments

Christoph Frehsee
Director Products and Services
MineWolf Systems AG
Pfäffikon SZ
Switzerland

Mini MineWolf withstands DM 11 + TM 57 mine stack: Only 2 chains damaged

Planting and Monitoring of WORM mines
Mini MineWolf with Remote Video Guidance System in Jordan
Remote Demining Operations with the Mini MineWolf

The increasing demand for safe and rugged robotic mine clearance vehicles for high-threat areas has resulted in the development and deployment of a light-weight, robust, armoured de-mining machine, the Mini MineWolf. Designed to provide maximum safety for human operators while surviving harsh environmental conditions and detonations up to 13.5 kg TNT the machine has demonstrated excellent results in trials and in the field: effective clearance of small AP mines, while surviving highyield AT mine blasts. The machine is equipped with a Remote Visual Guidance System and automatic depth penetration allowing operation from a safe distance with high-quality visual guidance of the working environment. A patented tiller design channels dust away from the camera allowing effective visual quality control. Optional tiller or flail working tools can be interchanged in minutes.

Currently deployed in 3 Countries, the machine has cleared over 1.8 million square meters of AP and AT mine contaminated land along in Bosnia, Croatia and the Jordan-Israel border during 2006-2007. During August-September 2007 the German Army conducted trials with the Mini MineWolf against simulated AP and live AT mines with up to 13.5 kg TNT. Both tiller and flail were successfully tested for effectiveness in clearing AP mines and survivability against 8 AT mine types, including stacked mines. AP mines were simulated using computercontrolled “WORM” mines (Wirelessly Operated Reproduction Mine) which are able to detect and report damage inflicted by the machine to a remote computer via a wireless link. The results of the trial were excellent, with the Mini MineWolf achieving impressive results close to 100% with both flail and tiller attachments against AP WORM mines. The Mini MineWolf also demonstrated outstanding survivability of both tiller and flail against heavy AT mine detonations.

De-mining techniques of improvised explosive materials by the usage of mobile robots.

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This paper demonstrates the de-mining techniques of the Improvised Explosive Device Disposal Unit (IEDD) that are in use for the neutralization of improvised explosive materials. The IEDD is a specialized unit which operates within the Department of Specialized Units of Kosovo Police Service (KPS) and is responsible for identification, training, transportation and neutralization of improvised explosive materials.

The IEDD members are involved only in cases of presence of the improvised explosive materials (suspicious bags, doubtful mines, deadfall mines, chemical explosives and explosives in general, as well as forays of high risk).

Improvised explosive materials can be of different shapes, but usually they are stored in different packages and with the first contact, they do not give the impression that could present any danger, in particular for human being or surrounding, except in cases when the terrorists who place those mines with intention to achieve considerable effect on threatening, rather than causing the eventual victims.

Since, the cases of emergency situation with mines have to be treated in specific way regarding the reaction methods as well as different scenarios, the IEDD Unit has applied the usage of mobile robot, carrying the mine detectors, could play here an important role.

Among the different ways robots could help IEDD Unit, the scenarios described in this paper regarding the detection and removal of mines are the most realistic.

Mobile robot Vanguard MK2B have been used in performing the adopted techniques in civilian mine clearance. Since, in the humanitarian de-mining, a high Clearance Efficiency (CE) is required, it can be achieved through the usage of robots supplied with cameras and sensitive sensors and their slow systematic displacements, according to well-defined procedures on the real terrain.

From the performed tasks in the terrain one can conclude that Robotic Systems can help the de-mining teams to improve the cost effectiveness and the safety of de-mining operations. However, based on the obtained results, it is expected in the future the robotic systems should be equipped with more open and reusable applications in completion the detection tasks in complex and dangerous areas.

Key words: Mobile Robots, De-mining Techniques, Control Process

Humanitarian De-mining Robot Gryphon - an Objective Evaluation

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Assisting human deminers or trained dogs in the mine searching task is challenging and expectations are high: the automation of the scanning increases safety for demining personnel and allows sensor imaging and automatic target recognition. This implies a new dimension for a more informed data evaluation with current landmine sensors and will represent at the same time an enabling technology for new sensors to come. Additionally, it is expected that this will increase demining pace and this at reduced cost. This paper presents a semi-autonomous mine searching robot named Gryphon that was developed with above goals in mind. It is made-up by a vehicle-mounted robotic manipulator capable to scan its surrounding terrain and generate precise sensor images. An operator remotely located monitors the scanning sequence and generated images, then registers suspect spots with GPS coordinates or with on-board marking systems. Gryphon was tested with two different metal detectors and various ground penetrating radar systems, and underwent several tests in Japan, Croatia and Cambodia. A discrimination method based solely on an off-the-shelf metal detector has also been tested in conjunction with Gryphon.

The test results and work experiences allow the authors to take a more critical and objective look at the validity of above mentioned expectations for humanitarian demining and the viability of the Gryphon system.

Agricultural derived tools for ground processing in humanitarian de-mining operations – set up of testing facility in Jordan

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As often acknowledged, humanitarian demining is mainly a gardening process. Because of its intrinsic threat, it requires extreme care, but the tools and the machines used for demining are very similar to equipment used in agriculture as the aim in the end is always ground processing. Nevertheless, mechanical technologies available on the humanitarian demining market are extremely expensive, the price of the cheapest machine being approximately 120.000 US$. Gardening tools as shovels and shears are used in support of manual demining operations but exceptions exist in which they become the prime demining technologies. This is the case of Sri Lanka and Jordan, where, due to particular environmental characteristics of soft sandy soil and small plastic anti personnel landmines, Norwegian People's Aid (NPA) has implemented the rake system. The method encompasses fully excavation by using simple hand rakes with longed handle. As final stage of the first author's PhD research into Participatory Agricultural Technologies (PAT) for Humanitarian Demining, involving the adaptation of power tillers to demining applications, the test of the module for ground processing tool to be attached to the power tiller - tractor unit will take place in Jordan in March 2008, supported by the Faculty of Agriculture of the University of Jordan and NPA Jordan.

After introducing briefly the project, the paper describes the design of the ground processing tool to be tested, the set-up of the testing facility in Jordan including the production of the tool supporting frame and the possible use of such facility for testing new tools derived from agricultural technologies targeting different soil and landmine environments.

Nuclear Quadrupole Resonance for explosive detection

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NQR is one of a promising new detector instead of a metal detector, because NQR can identify existence of explosives. We examined the NQR sensitivity of RDX and TNT. RDX of 100g can be detected up to 20 cm of depth under the ground by the NQR with less than 5 minutes. This sensitivity is enough to detect an anti-personal landmine buried under the ground. We have developed a small and light NQR detector to mount to a robot arm. It can be used in the landmine field, because it has design of noise cancellation such as a gradiometer. We have adopted to use multi pulse sequence method, so called SLSE to accumulate thousands of pulse signal to increase signal to noise ratio.

In a while, TNT cannot be detected well remotely. It is the reason why relaxation times of TNT are too long T1 such as seconds, and too short T2* such as less than a millisecond. Therefore, it is difficult to use a suitable pulse sequence method to accumulate many signals in order to reduce noise. More work is needed to improve sensitivity of NQR for TNT using double resonance method etc.

We made application research of NQR not to a landmine detector but also baggage inspection, shoe check and body check. As they work quite well to detect RDX remotely, they will be applied to the airport security instruments.

Exploitation of nonlinear dynamics in ferromagnetic and ferroelectric materials for novel high performances B-field and E-field Sensors

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Exploitation of smart materials and non linear dynamics is focused in this work with reference to the realization of innovative transducers. Ferromagnetic and ferroelectric properties have been mainly taken into account to develop sensors and actuators for various application fields.

Transducers exploiting the properties of FeSiB amorphous ferromagnetic micro-wires are presented. A highly sensitive magnetometer exploits the properties of such a magnetoelastic material core to detect and measure the presence of a few magnetic particles, for applications in either the biomedical or the security field. Such a fluxgate is based on two-coils structure (excitation coil and detection coil) wound around the ferromagnetic core having a hysteretic input-output characteristic. A Residence Times Difference has been exploited as readout strategy.

A nonlinear dynamical system based on ferroelectric capacitors coupled into a unidirectional ring circuit is considered, with particular interest in developing novel electric field sensors. The focused approach is based on the exploitation of circuits made up by the ring connection of an odd number of elements containing a ferroelectric capacitor. For such a device the presence of the weak, external, target electric field interacts with the system states thus inducing perturbation of the polarization status in the ferroelectric material, that can be indirectly detected and quantified via its effect on the oscillation frequency and on the asymmetry of the system output signals.

The dynamic behaviour of the ferroelectric ring is described by using the equations of the "quartic double well" potentials that model the ferroelectric capacitors, where the target electric field is considered as a perturbation in the polarization status of each ferroelectric element.
Simulation results have shown that for a coupling factor, between the ring cells, greater than the critical one, as related to the external field amplitude, a change in the harmonic content of the permanent oscillation generated in the coupled system occurs.
Advanced simulation tools have been used for modeling a system including electronic components and non linear elements as the conceived micro-capacitors. Moreover, Finite Element Analysis (FEM) has allowed to steer the capacitor electrodes design toward optimal geometries and to improve the knowledge of effects of the external target E-Field on the electric potential acting on the ferroelectric material.
Experimental characterization of the whole circuit, including three cells coupled in a ring configuration has been made also in this case. The results confirm the increasing of the circuit oscillation frequency as a function of the coupling factor, as expected from the mathematical and numerical models.

Work is currently in progress for all the listed transducers with numerous research activities which strongly promote the coupling of smart materials and their non linear properties exploitation for optimizing performance and often reduce costs of existing architectures.

Keywords: E-Field detection, ferromagnetic, ferroelectric, nonlinear dynamics, B-field detection.

A Complementary Multi-sensory Method for Landmine Detection

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One of the main needs for the humanitarian demining procedures is to find complementary sensing methods to fuse data supplied by multiple sources in order to maximize the detection of landmine and minimize the false positives. In this paper, a development of a multisensory method for a landmine detector is presented. This method is based on a multisensory fused data analysis on an embedded DSP, taken from an onboard camera and a metal detector.
The metal detector specially created for the application has the capacity to detect the landmine presence only if the mine has at least some small metallic components. This fact makes necessary to integrate another complementary sensory method with respect to the metal detector, given that the main goal is always to ensure the robot's safety, while false alarms rates are decreased. In order to do that, the onboard camera along with the embedded DSP have two purposes; first, to implement a navigation algorithm to find and follow nonstructured roads, which is extremely necessary due to the special characteristics of the Colombian territory and to perform tasks like 'demining along a road'. The second purpose is to analyze images of the road by taking account the color texture. Based on the color texture analysis, this research shows that it is possible to determine the presence of a non-metallic landmine within the image, achieved by finding the image regions whose color and texture features variations are considered anomalous. A color and texture variations over the image are an indicator that the surface has been intentionally modified and therefore it could be a landmine. This image processing strategy is being developed, in order to be implemented in 'Amaranta' robot, designed at Javeriana University - Colombia.

Fuzzy Template Based Automatic Landmine Detection from GPR Data

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In this paper, we present a 3D fuzzy template based anti-personal landmine automatic detection from GPR data. A 3D template is chosen and a 3D fuzzy template is designed. The choice of the 3D template is decided based on smooth changing position of the maximum amplitude at every C-scan as well as the threshold of its background average intensity. The 3D fuzzy template is extracted from 3D template crisp data. A data point in the 3D fuzzy template is expressed as a trapezoidal fuzzy set which is extracted from experimental data. Landmine similarity for both the 3D template as well as the learnt fuzzy template is examined by a crisp similarity measure and a fuzzy similarity measure respectively. The cross correlation is applied as a similarity measure in crisp case while a membership degree of a fuzzy set is applied as a similarity measure, in the fuzzy template case. Results of similarity applying both methods for automatic landmine detection from GPR processed data are presented. The results show the promise of 3D fuzzy template applying the fuzzy similarity measure in differentiating a landmine from other objects.

Landmine detection using integration of GPR and Magnetic survey

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The global landmine crisis is a critical problem facing many countries allover the world. It is estimated that a total of 45-50 million landmines remain to be cleared and more than 80 countries are affected by landmines and/or unexploded ordnance (UXO). Egypt as one of those countries is suffering of this problem and the development plans at north western part of Egypt are always a matter of delay mainly because of this problem.

Therefore, an attempt to use the GPR and the magnetic gradiometer techniques to detect the land mines was conducted. The main aim was to test these methods of surveying, measuring and inventing a prototype carrier. A special car (ESCALAD) was built for this purpose at the Egyptian Atomic Energy Agency (EAEA) supported by the international atomic energy agency (IAEA).The SIR 20 of GSSI GPR system connected to 1.4 GHz and 400 MHz antennas was used for the test while the magnetic gradiometer FM 36 was used to conduct the magnetic survey.

The results of this survey were promising, as the different kind of the land mines were detectable with considerable resolution, even before reaching the mine itself. The integration of the different techniques helped in enhancement of the recorded signals received from the landmine. The obtained results are helpful for constructing a visual model that could be used as the base of the next phase of the research plan which is the automatic detection and focusing around the position of the object.

Humanitarian Demining and the Challenge of Technology

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Landmines undermine peace and stability in whole regions by displacing people and inhibiting the use of land for production while subjecting people life to a continuous danger. Besides this, the medical, social, economic, and environmental consequences are immense. The variety of mines being used is enormous and a number of sources, such as pressure, movement, sound, magnetism, and vibration can trigger a landmine. What happens when a landmine explodes is also variable. Conventional landmines around the world do not have self-destructive mechanisms and they stay active for long time. Modern landmines are fabricated from sophisticated non-metallic materials. Humanitarian demining is a critical first step for reconstruction of post-conflict countries and it requires that the entire land area to be free of mines and hence it is necessary to locates and removes reliably and safely every single mine, and UXO from a targeted ground. Traditional military countermine solutions (techniques and equipment) are not directly applicable to humanitarian demining, largely because the philosophy and the standards for successful clearance are different. The problem associated with humanitarian demining is characterized by an enormous variability in the nature of explosive ordnance to be removed, climate diversity, and in the type of terrain and vegetation. Current demining is a dangerous, time consuming, and costly process. Hence, it becomes urgent to develop detection (individual mine, and area mine detection), identification and removal technologies and techniques to increase efficiency of demining operations by several orders of magnitude to achieve a substantial reduction to the threat of antipersonnel (AP) mines within a reasonable timeframe and at an affordable cost. Applying technology to humanitarian demining is a stimulating objective. To increase mine clearance daily performance by improving productivity and accuracy, and to increase safety of demining operations and personnel, there is a need for an efficient, reliable and cost effective humanitarian mine action equipment with flexible and modular mechanisms with adaptable mobility and equipped with some level of decision making capabilities. Most people in the mine clearance community would be delighted if the work could be done remotely through teleoperated systems or, even better, autonomously through the use of service robots. Detecting and removing AP mines seems to be a perfect application for robots. However, this needs to have a good understanding of the problem. Technologies to be developed should take into account the facts that many of the demining operators will have had minimal formal education and that the countries where the equipment is to be used have poor technological infrastructure for equipment maintenance, operation, and deployment. In addition, it is necessary to overcome the constrain on the resources by developing innovative, cost effective and practical technology inspired by locality and real minefield needs to help in speeding up the demining process and enhance accuracy, productivity, operation and personnel safety, achieve a higher quality of the service, and contribute to local economy.

Legged robot - Animal cooperation to trace smell gradients in minefields

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This paper presents the results of real world experiments done on legged locomotion of a robot in cooperation with a rodent called a mongoose in a task to navigate in an unstructured forest environment to detect antipersonal landmines. The task of the legged robot was to guide the rodent along pre-defined paths in a vegetated environment, and to learn locomotion skills from the rodent. Many studies have been conducted on legged locomotion of robots in the recent past due to promising benefits such as improved efficiency in a wide class of soil conditions, the ability to cover the full spectrum from walking to galloping, or even hopping [1]. Yet, there are many problems yet to be solved such as how to optimize the speed given a payload [2], how to distribute the force structure among the legs in an optimum manner [3], and how to optimize the gait patterns given a terrain condition [4].

The task of the rodent was to sniff the ground to find gradients of explosive smell traces and to provide teaching signals to the legged robot to learn how to navigate in a vegetated environment with rough terrain conditions. Therefore, in the proposed system of an animal and a robot as shown in **figure 1**, both systems benefit from each other. Current finding show that the coupled system can locate small amounts (~1g) of explosives buried under 6 inches of soil from 3m away.

Figure 1: The coupled system of a trained rodent and a legged robot.

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Data Association for Robot Localization in Satellite Images

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Autonomous navigation of robots has been of immense research interests since the beginning of robotics. Much progress has been made in the area but a fully functional autonomous navigation system has yet to be developed. To reach a reasonable degree of autonomy, two basic requirements are needed: sensing and reasoning. Sensing is provided by an on board sensory system that gather information about the robot itself and the surrounding environment. According to the environment state, the reasoning system must allow the robot to localize itself in the environment and to seek for free paths.
However, the problem is more complicate when the robot has to navigate from an unknown location in an unknown environment. In this case the robot should have the means to build a map of the environment using only relative observations of the environment and then use this map to localize and navigate. This problem is known as Simultaneous Localization and Mapping (SLAM) problem.
A key weakness of SLAM methods is their dependence on data association which is the process of corresponding data measurements with the representation of the environment. Any incorrect data association will result in the map to converge to the wrong state and thence a false localization of the robot.
This paper presents an algorithm capable of combining data from different sensors to localize an outdoor autonomous mobile robot in a user defined global coordinate frame on geo-referenced images. The algorithm uses an Extended Kalman Filter EKF to integrate information data from camera images, wheel encoders, steering angle encoder, and GPS to build a map for the environment and localize the robot in satellite images. The user can then communicate with the robot to define a final goal (target) using only the satellite images.

Cognitive Theory – Based Approach for Inspection using Multi Mobile Robot Control.

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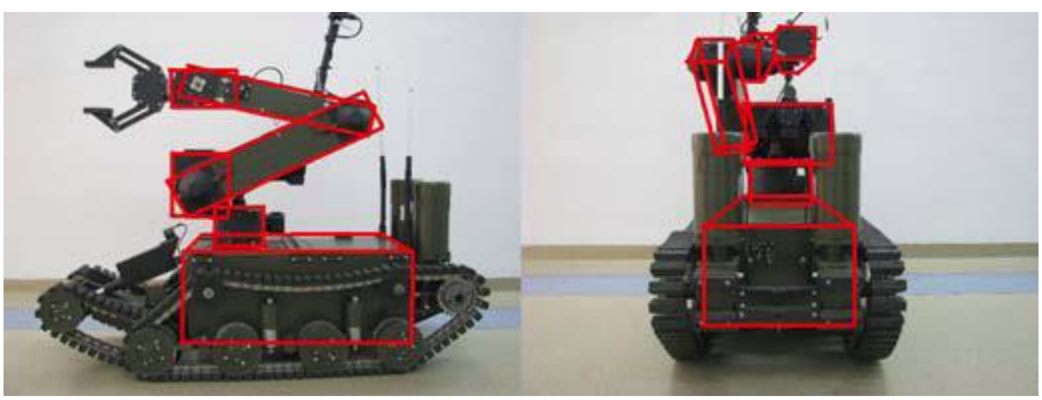
The following paper describes the Cognitive Theory – Based Approach of multi mobile robot control. The main goal of the approach lays on the implementation of the decision selection which is provided by the model of human supervisor. The application of the model is rendered on its cognitive attributes and ability to control the robot by the vision and chemical sensors based perception. Therefore, the structure of the process supervision from the remotely controlled sophisticated system and the autonomous robots are presented. Hence, the structure with the autonomous robots system are cooperating each other to render a new generation system inspection.

The new generation inspection system is marked by the availability of the human – robot interaction system in the structure. To achieve this interaction, the human machine interface as a mean to construe the real cognitive system interaction into modelled/ simulated interaction have to be implemented. The interfaces are implemented in server – client scheme, because the mobile platforms are prepared to cooperate in distributed control system. All the cooperation shown above require a kind of complex architecture which can be derived from CORBA. This paper as well has shown how the architecture is applied and in general inducing an idea of robot Tele-operation.

In managing the complexity of the attributes of the system as described above, then the behavioral conceptual adoption should be applied. This application succeed it's intelligence system by perpetuating the decision selection system which based its operation by the fuzzyARTMAP algorithm system. This skill is a prominent achievement which leads into the perceptual associative memory, as another essential attribute of the systematic cognitive system that this research lends it's concept.

The perceptual associative memory in this system particularly rendered by an ability to interpret the incoming stimuli by recognizing individuals or objects, categorizing them and noting the relationships between the objects and categories. These attributes mentioned above are showing the pertinent robot action which are always consistent with the categories and their relations.

So far, the study has able to provide the new approach of the robot's cooperation system. In the application, the mobile robot ATRVJr is accompanying the Tele-operated robot INSPECTOR with its' mobile platforms are to be able to execute some autonomous and semi autonomous tasks.



Meanwhile, the main goal for the mobile robot it self is to acquire data from the environment and delivers into Command Operation Center through the wireless communication system . The COC is functioned by the existing system of the cognitive modelled of human supervision which perceptually and behaviourally are able to recognize and execute the procedures needed in the case of some risky events, particularly the collision problems. Therefore the two substantial jobs from the perception and association action by mapping and localizing tasks are achieved by the system

Framework for Creation of the Simulators for Inspection Robotic Systems

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In the paper research activities concerning framework for creation of the simulators for Inspection Robotic Systems will be described. The goal of the project is to build computer framework which will be used to simulators design for training of the operators for inspection robots and to make software for the simulators.

The use of inspection robots is essential in categories like antiterrorism, crime prevention, safety of the people and their goods. They substitute human in dangerous situations, for example carrying the bomb. Training of the operators of the robots is necessary to improve the process of manipulating the robot and carried package in order to decrease the danger for surroundings and people nearby. Complex training using real machine is very expensive and surely impossible to carry out due to the cost of the robot, its maintenance and variety of possible situations that operators could face. This situation cause that computer simulators are needed. They can be designed and produced using a framework.

This paper describes few steps of the creation of the framework. There are several issues that should be considered, i.e. role of instructors, type of tools needed for creation of the scenarios, type of information received as result of training, etc., because that kind of frameworks doesn't exist (or exists only for private use, not commercial).

At the beginning, methodology of the training should be elaborated. First, information about users' needs and expectations should be gained. Also recognition if there are any trainings methods available among the producers and users of the robots is necessary. Following steps are: designing the methodology of the training and initial selection of the simulators, verification of the designed methodology and selection of the simulators with cooperation with users and producers of the robots.

Developing the project of the framework for chosen set of the simulators is the next step. At this stage definition and analysis of user requirements should be done. Then describing the vision of the system could be possible. This part of designing should take into account the information about either commercial or provided by the robot's manufacturer components of the system. Afterwards the project of the system could be completed.

Last stage of the creation of the framework is to implement and run the software. Technical tests and trials are unavoidable, because they show if there are any mistakes, made during the developing, that should be corrected. Designing and creation of the exemplary simulator should be carried out in order to test the functionality of the framework and it would be the final exam for this software.

A Fuzzy Approach for the Control of Autonomous Vehicles Operating in Hazardous Terrain Environments

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The aim of this article is to present a description of the design of a fuzzy based controller for the navigation of autonomous vehicles in hazardous environments, in particular for de-mining robots. The reason for the selection of a fuzzy based approach is to handle uncertainty in navigational decisions due to the encountering of a mine or to avoid an obstacle. This uncertainty which exists within many autonomous systems is amplified by the unstructured and rough nature of the terrain which may require the vehicle to circumnavigate certain surface features.
The approach is based on a reactive control architecture which reacts towards sensed information about the immediate environs of the vehicle's current position in relation to the target position and makes an intelligent decision of the navigational act to be taken. The system utilizes a fuzzy controller in order to cater for the uncertainty and ambiguity associated with the nature of the surface terrain. Initially, the controller determines the local position of the vehicle in relation to the reference frame.
Subsequently, it performs a fuzzification of the target position as well as the fuzzification of any obstacle detection distances. The inference mechanism of the controller operates on these inputs through a set of heuristic strategy knowledge rules stored in a rulebase. The set of applicable rules are determined and their results are defined in terms of membership for the fuzzy function. A single navigational decision based on these functions is sought. A fuzzy fusion technique is utilised to combine the results of all valid rules in order to obtain a crisp navigational decision. The output of this fusion process is defuzzified in order to obtain a discrete navigational action for the actuators of the vehicle.

Virtual Training System for Teleoperation of ROBHAZ-DT2

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Recently various field robots have been developed for hazard environment applications (e.g. explosive ordnance disposal, rescue, security), and most of them employed master-slave system by using Tele-operation control scheme. To complete given missions in outdoor environment, the slave robot must have appropriate functions, accuracy and reliability, and the ROBHAZ, a mobile manipulator system, was developed in our previous research. However, the more functions the slave robots have, the more difficulties occur in operation of the functions. To cope up with this problem, an effective user interface was also developed for the ROBHAZ. For evaluation and optimization of the user interface, it should be verified in several tens of practical operations, but it is difficult to use actual robots for every turns of the verifications. Because most slave robots are expensive, it is reluctant to use actual robots for training. A virtual reality system is useful not only to evaluate the user interface for slave robots but also to train operators. This paper describes a virtual training system for ROBHAZ. The slave robot is simulated in virtual environment, and the operator interacts with OpenGL based 3D graphics. In the virtual training system, a new user interface was easily verified, and operators are effectively trained without actual robot.

Heterogeneous robot cooperation for interventions in risky environments

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In this work we will present the architectures and some experimental results of two examples of heterogeneous robot cooperation that have been designed to be adopted to reduce risk for human in the intervention in risky environments.

In particular we explored the cooperation among mobile terrestrial platforms and climbing robots and of aerial vehicles and mobile terrestrial platforms.

In the first example the cooperation between a climbing robot for inspection of vertical walls and a rover for outdoor operations has been tested. The mobile robot can position the climbing robot close to the dangerous area allowing human operators to remain at a safe distance.

A new autonomous climbing system based on vortex adhesion has been developed. In order to achieve very low system weight and relatively high payload, a new smart active suction cup was designed and built. The vacuum inside the cup is generated by means of a high speed centrifuge fan that create a vortex with a low pressure area in the central zone. By using this principle it is possible to use a low power brushless motor to actuate the fan (about 50W). In this way no exhaust air flow is generated, and consequently the process is more efficient with respect to suction cups where an aspirator is used instead to generate the vacuum [1]. This kind of vacuum cups can adhere to different kind of rough surfaces because it can sustain vacuum inside, without using any sealing. A strong adhesion force is achieved even when a considerable gap (<1cm) between the robot and the surface is present. This allows reducing to zero the friction between the cup and the wall, to save energy, to increase robot speed. Moreover it permits the robot to move over small obstacles or irregularities and to climb from a floor to a wall. The robot use four independent DC motors and four wheels to move and use an inclinometer as feedback sensor in order to follow a reference trajectory during its travel over a surface.

The robot has been tested over many different surfaces giving good results. A particular test was performed by using the mobile outdoor robot ROBOVOLC [2], in order to put the climbing robot on a vertical surface with the operators at a safe distance. The rover ROBOVOLC was teleoperated from a base station, by using several cameras. Once a contact with the wall was achieved a command was given to the climbing robot that could start the climb of the wall. On board of the climbing robot another camera with a radio link was present in order to permit a careful inspection of the surface.

Fig.1 Terrestrial rover – Climbing robot cooperation.

In the second example we propose the adoption of a UAV [3] to help localization and mapping of terrestrial vehicles [5].
In particular an innovative method for aerial target geo-localization is used to determine at the same time the position of a rover and of a natural/artificial target [4]. The enhancement proposed in this work is represented by the use of the information provided by the Differential GPS mounted on the rover to increase the precision in the estimation process of the targets positions. The proposed approach, uses the knowledge of rover position to correct the transformation matrixes. The parameters of transformation matrixes are used as state variable in a Kalman Filter. Rover position is well known by using a Kalman Filter based on sensor fusion between DGPS and odometry raw data. In such a way, to enhance the accuracy in the estimation process, the camera has to collect just few frames of the ground robot.
Once corrected the transformation matrixes, the position of the landmarks can be well estimated; for example it is possible to estimate the destination point of the Rover path.

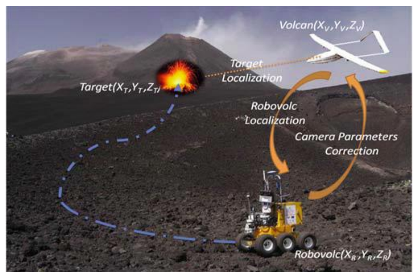

Fig.2 Terrestrial rover – UAV cooperation

In the full paper further details on the described systems will be exposed and the results of several simulations performed will be presented and commented.

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HIL tuning of UAV for exploration of risky environments

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In high risk environments the use of UAV represents an efficient solution to increase response efficiency and quickness, reducing risk for involved human operators.

In order to carefully set up a control system of a robotic system, many field experimental trials are needed. In particular in the case of tuning the autopilot of a flying machine, this is even more difficult because of the high risk of damaging the machine, in case of wrong tuning parameters. Therefore, in UAV developing phase, a Hardware in the Loop (HIL) architecture is an efficient methodology that allows reducing time, costs and risks [1],[2].

In the paper we will present the latest results of an HIL architecture optimized to develop and test UAV platforms. The proposed architecture is strongly modular and flexible and allows testing hardware and software of each module individually, eventually replacing the other modules and the vehicle dynamics with a simulator.

The flight simulator (XPlane) with suitable plane model and plugin, has been adopted to simulate the UAV dynamics. The flight simulator can be interfaced with the real signal coming from or sent to the autopilot electronic board, allowing an easy tuning of all the control parameters and data collecting for test and validation.

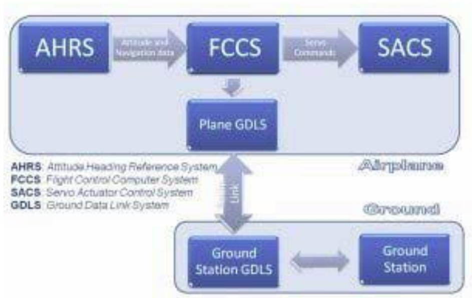

Fig.1 Block diagram of the avionic system.

This architecture has been used to develop and realize the different devices involved in the navigation and stability control of the vehicle: an Air Data Attitude and Heading Reference System (ADAHRS), a Flight Computer Control System (FCS), a Servo Actuators Control System (SACS) and a Ground Data Link Systems (GDLS) have been tuned and tested in HIL simulations.

The validity of adopted methodology was confirmed by several flight tests performed subsequently by using the designed autopilot on a real UAV.

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AMARANTA: Modular Platform for a Mine Hunting Robot

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Mine hunting robots must navigate in dangerous and irregular surfaces which may also have obstacles. This paper presents the development and full performance of a robot for navigating on high risk terrains. Its design is based on a four leg-wheel system which makes it more robust for this type of environment.
Each leg-wheel has three degrees of freedom corresponding to the turn and direction of the wheel as well as to the flexion or extension of the leg. This makes the robot to moves in any direction on the surface and thusly moves its main framework up and down. Since the robot may move using three of its four legs, this makes it capable of overcoming obstacles whereas a robot made up of only wheels would be blocked up. Hence, one gets information on the force exerted upon each leg which allows to arrange the robots' posture depending the surface qualities.
The *Amaranta* robot is completely modular. This is a considerable advantage for high risk environments. Each leg-wheel has its own control system which in case of accident allows to change only the damaged leg. This means that in the case of an explosion the damages are minimized, thusly making it easier to repair the platform.

De-mining in Shallow Inland Water Areas

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According to studies, out of the 70 million mines deployed worldwide 15% are laid in shallow inland water areas. As these areas pose a serious mobility challenge to vehicles and humans as well - due to deep mud and low visibility under water - they deserve special attention. Some of these areas regularly freeze over in the winter making it possible for lightweight robotic vehicles to traverse them. When moving on low definition surfaces such as ice or sand, vision based Tele-operation becomes difficult, and special methods have to be applied. Operating metal detectors, or ground penetrating radars in waterlogged areas can also be challenging. In this paper a special case study is presented, an ice rover, capable of moving around on the ice and carrying equipment, enabling it to map metallic objects in the water such as mines, unexploded ordnance and historic artifacts. The main problems associated with the task at hand, teleoperation and navigation issues, sensor suite and data processing problems, and contemporary research on these problems are presented.

Keywords: shallow water de-mining, Tele-operation in low definition environment, ice rover, UXO, underwater exploration

Robotic Assistance in Extreme Conditions

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Robotic assistance in hazardous conditions is analyzed on the base of some Russian organizations experience. The suggested robots are intended for humanitarian de-mining, fire-fighting and decontamination applications.

Last years robotic activities for hazardous conditions are growing as an often dangerous incidents origination. Some results of the research, development and testing of extreme robotics are delivered.

The mobile robot design on the base of mechatronic approach is one of important tendency to improve the adaptivity to environments and to increase main working parameters. Multifunctional mobile robot complex of light and superlight classes are under consideration. Mine detecting methods examine in relations with applications in robotics.

Special attention concentrate on modular fire-fighting robot design because of several modifications of such robots are manufacturing and applied depends on fire solved tasks.

New design solutions are discussed for robotized fire complexes application, providing automatic fire extinguishing of high-floored buildings by water and foam, where application of traditional technical equipment is ineffective and unacceptable.

Model-Based Soil Parameter Identification For Wheel-Terrain Interaction Dynamics

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Terrestrial robots used for environmental surveillance, risky interventions and humanitarian de-mining have to operate in unstructured outdoor environments. The interaction dynamics between the wheels of such robots and the outdoor environment play a crucial role in traversability prediction, traction control, and performance optimization. From wheel-terrain interaction dynamics, it is seen that wheel slip and soil parameters play a vital role in determining vehicle drive forces. Thus, knowing the soil parameters of the terrain on which a vehicle is moving is beneficial for controlling the vehicle. In this paper we develop an algorithm for identifying soil parameters for wheel-terrain interaction dynamics. This paper presents a method to identify the set of soil parameters required to predict drawbar pull and wheel drive torque from measurements of slip, sinkage, and drawbar pull for a wheeled vehicle traversing unknown terrain. The soil parameters identified are internal friction angle, shear deformation modulus, and lumped pressure-sinkage coefficient. A 2-stage iterative Newton Raphson (NR) method is used for soil parameter identification. Simulation results show successful identification of a complete set of soil parameters with relatively fast speeds. The algorithms are also tested using experimental data obtained from a specially designed test rig where wheel slip can be accurately controlled and measured. Test results show that the algorithm can identify the soil parameters accurately and robustly with relatively fast speeds. The identified soil parameters are then used to predict the vehicle driving forces at various slip values and correlated to experimental measurements. The drawbar pull and wheel drive torque predicted from the identified soil parameters are shown to be in good agreement with their measured values. It is shown that the drawbar pull and wheel drive torque can be effectively predicted and used to for vehicle performance optimization. The algorithms presented in this paper can be used to develop traction control algorithms for off-road robots operating in rough terrain.

Robotised Combine to demining of mine fields

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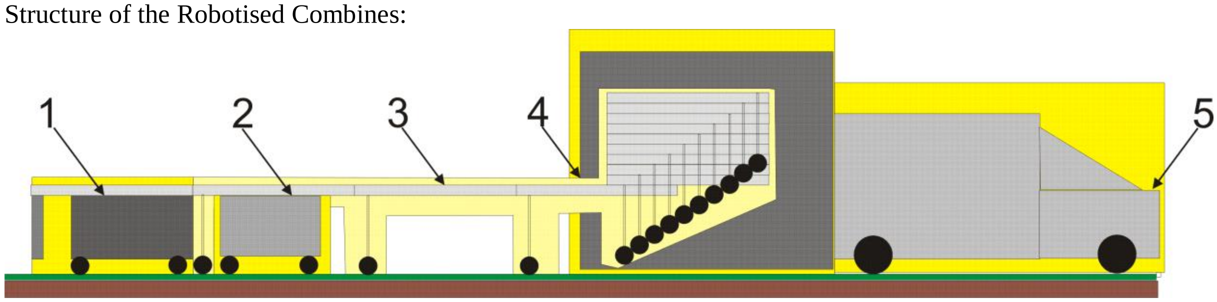
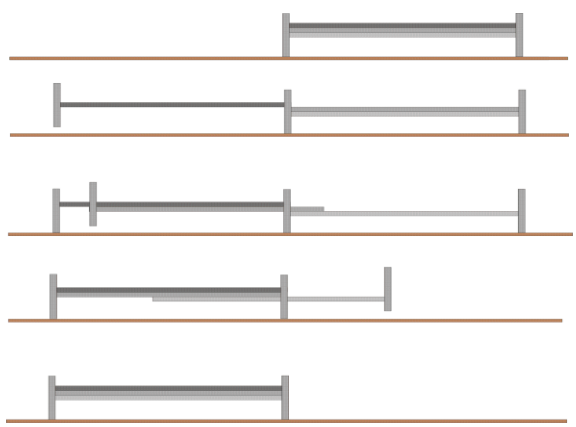
The Robotised Combine is version of Robotised Combines from Robotised Complexes to ecological produce to fruits and vegetables on the open areas, specific to produce of melon and watermelon and to produce of seedlings.
Structure of the Robotised Combines:



1. Working Module (Demining Module).
2. Forwarding Module.
3. Rail Modules.
4. Main Module.
5. Automobile.

I. The De-mining Module is walking by means of Rail Modules and have:

1. Portal Robot (De-mining Robot) with sensors and tools for action to de-mining and store of deactivate mines in specific packing for transportation. жертви,
2. Portal Robot for store action - execute transference on specific packing from De-mining Module to Forwarding Module and return.
3. Walking Robot for shifting to De-mining Module within the band for de-mining. The principle of action is:



The Walking Robot has 4 vertical linear steppe of freedom and 4 horizontal linear steppe of freedom. Walking Robot have and sensor system for detecting for mines and coordinates of the mines in next zone to demining.

4. Additional equipment.

II. Forwarding Module forwards the packing between Demining Module and Main Module and is automatic platform and has motion over deployed Rail Modules.

III. Rail Modules is passive elements and serve for fixing to motion on Demining Module. The Rail Modules way for Forwarding Module is no more from 150 m. By means of Rail Modules have transfer of the necessary power from Main Module to Demining Module for work and signals for the control and for the checking.

IV. Main Module expends and collects Rail Modules and shift Robotised Combine without Automobile of new band for demining of the mine field. In the Main Module have source to power (photovoltaic), transformer to power, accumulators, systems for control and checking. By means of The Mail Module have transfer to the packing from Forwarding Module and from Automobile and back.

V. Automobile have function to transport of deactivate mines next to place for elimination. The drivers of the automobile is and operators to the Robotised Combine.

The Robotised Combine have possibility to be demining of mixed mine field with mine surprise, as have possibility to work at slope with angle next to 45°and at small unevenness of the mine fields. Every one element for assembling of Robotised Combine is really.

Generally:

1. The product “SNIFEX”
2. Indicators for metal
3. Micro video cameras
4. Vacuum and micro pneumatic grippers
5. Telescopic electromechanical modules for linear shift as “HTR” of PARKER and as “MovoZ Z3” of THOMSON TOLLO.
6. Pneumatic cylinder
7. Etc.

General tasks:

1. Maximum speed for demining of mine fields, Possibility of Robotised Combine to work double tides as:

a/ drop off innocent human victims.

b/ more areas for produce of ecological fruits and vegetables

c/ etc.

2. Safety works
3. Etc.