MULTI-TERRAIN ROBO DESIGN

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ABSTRACT

Due to the rapid progress in the field of robotics, it is a high time to concentrate on the development of a robot that can man in all type of landscapes, ascend and descend stairs and sloping surfaces autonomously. This paper presents details of a prototype robot which can navigate in very rough terrain, ascend and descend staircase as well as sloping surface and cross ditches. The robot is made up of six differentially steered wheels and some passive mechanism, making it suitable to cross long ditches and landscape undulation. Static stability of the developed robot have been carried out analytically and navigation capability of the robot is observed through simulation in different environment, separately. Description of embedded system of the robot has also been presented and experimental validation has been made along with some details on obstacle avoidance. Finally the limitations of the robot have been explored with their possible reasons.

INTRODUCTION

Multi Terrain Robots are the category of mobile robots that are capable of showcasing excellent off-road performances. They are able to navigate across bumpy and rough terrains. They mainly have wheels or tracks for locomotion. ATRs have various link mechanisms in order to overcome various sized obstacles. It is always desirable that the ATRs will be autonomous, that is, it will sense its environment with the help of sensors and then will take further decision on its own, with the help of instructions. The goal of this work was to conceive and build a mobile robot which will be a wheeled rover having good off-road capabilities, good grip over undulating, rough terrain, variable size obstacle negotiation capability, staircase ascending and descending capability, ditch/crevasse crossing capability and generating stable motion in undulating surface.
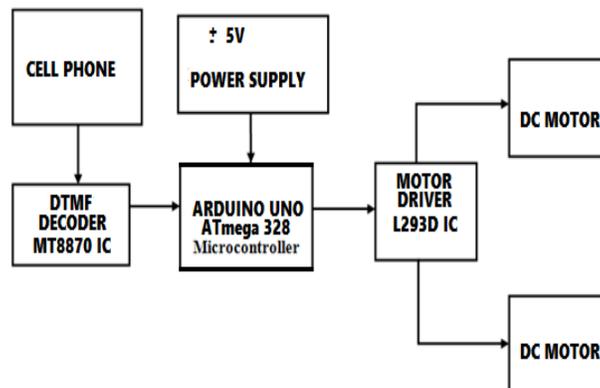
BLOCK DIAGRAM

Fig 2.1 Block Diagram of Multi Terrain Robo

HARDWARE COMPONENTS
3.1 BLUE TOOTH

Bluetooth is a standard used in links of radio of short scope, destined to replace wired connections between electronic devices like cellular telephones, Personal Digital Assistants (PDA), computers, and many other devices. Bluetooth technology can be used at home, in the office, in the car, etc. This technology allows to the users instantaneous connections of voice and information between several devices in real time. The way of transmission used assures protection against interferences and safety in the sending of information.

Between the principal characteristics, must be named the hardiness, low complexity, low consume and low cost. The Bluetooth is a small microchip that operates in a band of available frequency throughout the world. Communications can realize point to point and point multipoint.

How it works?

Every device will have to be equipped with a microchip (transceiver) that transmits and receives in the frequency of 2.4 GHz that is available in the whole world (with some variations of bandwidth in different countries). Besides the information, there are three channels of voice available.

The information can be exchanged to speeds of up to 1 megabit for second (2 megabits for second in the Second Generation of this Technology). A scheme of "frequency hop" (jumps of frequency) allows to the devices to communicate inclusive in areas where a great electromagnetic interference exists. Besides that is provided with schemes of encryption and check.

Frequency Bands

 The standard Bluetooth operates in the band of 2,4 GHz. Though worldwide, this band is available, the width of the band can differ in different countries. This is the frequency of band of the scientific and medical industries 2.45 GHz (ISM*). The ranges of the bandwidth in The United States and Europe are between 2.400 to 2.483,5 MHz and it covers part of France and Spain. The ranges of the bandwidth in Japan are between 2.471 to 2.497 MHz. So the system can be used worldwide due to that the transmitters of radio covers 2.400 and 2.500 MHz and it is possible to select the appropriate frequency. This ISM* is opened for any system of radio and must take care of the interferences of monitors for baby, the controls for doors of garages, the wireless telephones and the microwave ovens (the source with higher interference).

| Country	Frequency Range	RF Channels	
Europe* & USA	2400 - 2483.5 MHz	f = 2402 + k MHz	k= 0,...,78
Japan	2471 - 2497 MHz	f = 2473 + k MHz	k= 0,...,22
Spain	2445 - 2475 MHz	f = 2449 + k MHz	k= 0,...,22
France	2446.5 - 2483.5 MHz	f = 2454 + k MHz	k= 0,...,22

Power

The equipments of transmission are qualified in 3 groups according to the level of power of emission, as we can see below. The recipient equipment must possess a sensibility of at least 70 dBm, and the rate of admissible mistake must be a minor or equal to 0,1 %.

Device Power Class	Maximum Permitted Power mW(dBm)	Range (approximate)
Class 1	100 mW (20 dBm)	~100 meters
Class 2	2.5 mW (4 dBm)	~10 meters
Class 3	1 mW (0 dBm)	~1 meter

Protocols

Different applications can operate under different sets of protocols; nevertheless, all of them have a link of information and a physical cap common Bluetooth.

The figure below shows the set of protocols:
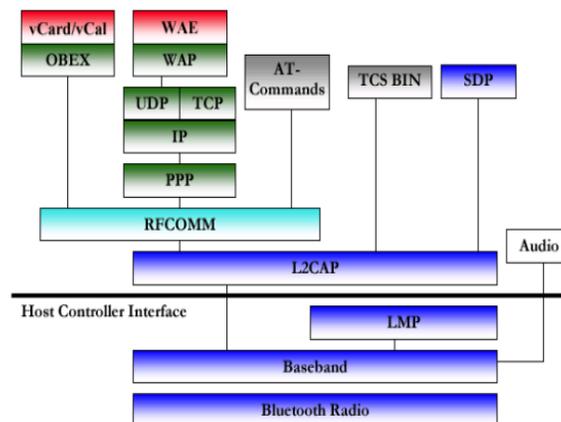
Fig 3.1 Block diagram of Protocols of Blue tooth

3.2 REGULATED POWER SUPPLY

In mains-supplied electronic systems the AC input voltage must be converted into a DC voltage with the right value and degree of stabilization. In these basic configurations the peak voltage across the load is equal to the peak value of the AC voltage supplied by the transformer's secondary winding. For most applications the output ripple produced by these circuits is too high. However, for some applications - driving small motors or lamps, for example - they are satisfactory. If a filter capacitor is added after the rectifier diodes the output voltage waveform is

improved considerably. The section b-c is a straight line. During this time it is the filter capacitor that supplies the load current.

The slope of this line increases as the current increases, bringing point c lower. Consequently the diode conduction time (c-d) increases, increasing ripple. With zero load current the DC output voltage is equal to the peak value of the rectified AC voltage. Figure shows how to obtain positive and negative outputs referred to a common ground. In particular they are helpful in determining the voltage ripple for a given load current and filter capacitor value. The value of the voltage ripple obtained is directly proportional to the load current and inversely proportional to the filter capacitor value. The performance of a supply commonly used in consumer applications – in audio amplifiers.

Often the degree of stability provided by the circuits described above is insufficient and a stabilizer circuit is needed. This circuit is often used as a reference voltage to apply to the base of a transistor of to the input of an op amp to obtain higher output current. The simplest example of a series regulator is shown in Figure. In this circuit the transistor is connected as a voltage follower and the output voltage is about 600 - 700mV lower than the zener voltage.

The resistor R must be dimensioned so that the zener is correctly biased and that sufficient base current is supplied to the base of Q1. For high load currents the base current of Q1 is no longer negligible. To avoid that the current in the zener drops to the point where effective regulation is not possible a Darlington may be used in place of the transistor. When better performance is required the op amp circuit shown in Figure is recommended. In this circuit the output voltage is equal to the reference voltage applied to the input of the op amp. With a suitable output buffer higher currents can be obtained. The output voltage of the Figure 14 circuit can be varied by adding a variable divider in parallel with the zener diode and with its wiper connected to the op amp's input.

The design of stabilized supplies has been simplified dramatically by the introduction of voltage regulator ICs such as the L78xx and L79xx - three-terminal series regulators which provide a very stable output and include current limiter and thermal protection functions. Regulated power supply is mainly used to providing power to this project because it is providing regulated dc power and it converts 220v ac supply into regulated dc power of 5v, 9v, 12v, 15v etc. Regulated power supply consists of step down transformer, bridge rectifier which is combination of 4 diodes connected in bridge shape. Bridge rectifier has the maximum efficiency and it is best than other rectifiers that's why we prefer it. This rectifier converts ac into pulsating dc. After rectifier filter circuit is employed, usually capacitor in parallel is used as filter or we can use number of capacitors in parallel and number of inductors in series. All these filters are low pass filters as we required dc at the o/p. Then after capacitor voltage regulator is used for observing the pure dc o/p. We can use various voltage regulators for obtaining pure dc o/p but we prefer 78xx series voltage regulators as they are simpler, cheaper and easier than others.
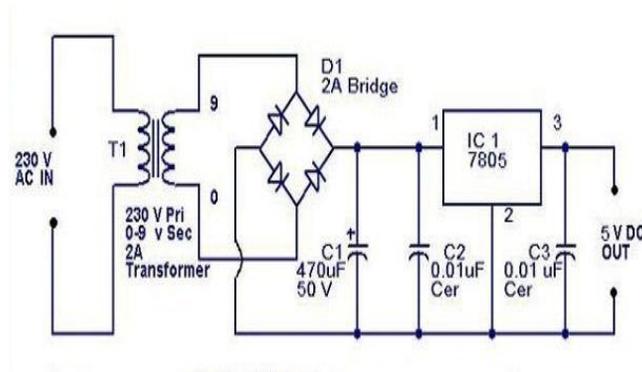
Fig. 3.2: Circuit diagram of regulated power supply section

1) AC Input: This is the input supply from the public utility where the device will be energized. It is also supplied directly to the relay contacts in the device which connects the load to the supply when the supply is within 200V – 240V range.

(2) Step down transformer: It steps down the AC supply into 5v on the secondary side. It is therefore a 230/5 v transformer. Any change in the primary reflects in the secondary of the transformer. So any fluctuations   in the input are also reflected as a fluctuation in the output.

(3) Rectifier: A center tapped transformer, with four diodes for full wave rectification is used to convert the ac voltage to a pulsating dc voltage followed by a filter, comprising of a capacitor to filter out (smooth) the pulsation. After the rectification and smoothening, a sample of the output voltage is fed to the micro controller. This voltage is unregulated and therefore varies as the input mains voltage varies. Since the system is to prevent against over voltage, the transformer was designed and the windings were so selected for the device to be able to sense and withstand input mains voltage up to 600Vac.
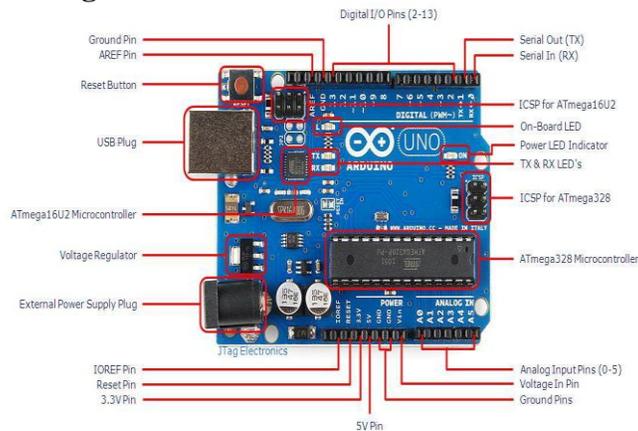
3.3 ARDUINO
Introduction to the Arduino Board

The Arduino is a family of microcontroller boards to simplify electronic design, prototyping and experimenting for artists, hackers, hobbyists, but also many professionals. People use it as brains for their robots, to build new digital music instruments, or to build a system that lets your house plants tweet you when they're dry. Arduinos (we use the standard Arduino Uno) are built around an ATmega microcontroller essentially a complete computer with CPU, RAM, Flash memory, and input/output pins, all on a single chip. Unlike, say, a Raspberry Pi, it's designed to attach all kinds of sensors, LEDs, small motors and speakers, servos, etc. directly to these pins, which can read in or output digital or analog voltages between 0 and 5 volts. The Arduino connects to your computer via USB, where you program it in a simple language (C/C++, similar to Java) from inside the free Arduino IDE by uploading your compiled code to the board. Once programmed, the Arduino can run with the USB link back to your computer, or stand-alone without it no keyboard or screen needed, just power.
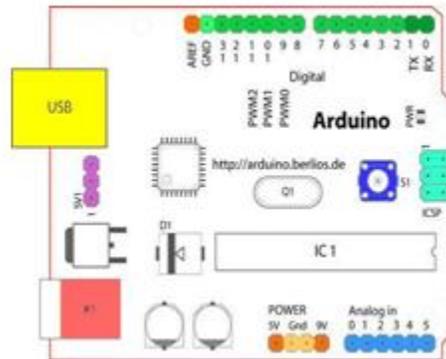
Figure 3.3 Structure of Arduino Board

Figure3.4 Arduino Board

Looking at the board from the top down, this is an outline of what you will see (parts of the board you might interact with in the course of normal use are highlighted).

Starting clockwise from the top center:

Analog Reference pin (orange)

> ➢ Digital Ground (light green)

> ➢ Digital Pins 2-13 (green)

> ➢ Digital Pins 0-1/Serial In/Out - TX/RX (dark green) - These pins cannot be used for digital i/o (DigitalRead and DigitalWrite) if you are also using serial communication (e.g. Serial.begin).

> ➢ Reset Button - S1 (dark blue)

> ➢ In-circuit Serial Programmer (blue-green)

> ➢ Analog In Pins 0-5 (light blue)

> ➢ Power and Ground Pins (power: orange, grounds: light orange)

➢ External Power Supply In (9-12VDC) - X1 (pink)

➢ Toggles External Power and USB Power (place jumper on two pins closest to desired supply) - SV1 (purple)

➢ USB (used for uploading sketches to the board and for serial communication between the board and the computer; can be used to power the board) (yellow)

Digital Pins

In addition to the specific functions listed below, the digital pins on an Arduino board can be used for general purpose input and output via the pin Mode(), Digital Read(),and Digital Write()commands. Each pin has an internal pull-up resistor which can be turned on and off using digital Write() (w/ a value of HIGH or LOW, respectively) when the pin is configured as an input. The maximum current per pin is 40mA.

➢ **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. On the Arduino Diecimila, these pins are connected to the corresponding pins of the FTDI USB-to-TTL Serial chip. On the Arduino BT, they are connected to the corresponding pins of the WT11Bluetooth module. On the Arduino Mini and LilyPad Arduino, they are intended for use with an external TTL serial module (e.g. the Mini-USB Adapter).

➢ **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, arising or falling edge, or a change in value. See the attach Interrupt()function for details.

➢ **PWM: 3, 5, 6, 9, 10, and 11** Provide 8-bit PWM output with theanalog Write()function.On boardswith an ATmega8, PWM output is available only on pins 9, 10, and 11.

➢ **BT Reset: 7.**(Arduino BT-only) Connected to the reset line of the bluetooth module.

➢ **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication, which,although provided by the underlying hardware, is not currently included in the Arduino language.

➢ **LED: 13.** On the Diecimila and LilyPad, there is a built-in LED connected to digital pin 13. Whenthe pin is HIGH value, the LED is on, when the pin is LOW, it's off.

Analog Pins

In addition to the specific functions listed below, the analog input pins support 10-bit analog-to-digital conversion (ADC) using the analog Read()function. Most of the analog inputs can also be used as digital pins: analog input 0 as digital pin 14 through analog input 5 as digital pin 19. Analog inputs 6 and 7 (present on the Mini and BT) cannot be used as digital pins.

Power Pins:

➢ **VIN** (sometimes labeled "9V"): The input voltage to the Arduino board when it's using an externalpowersource (as opposed to 5 volts from the USB connection or other

regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin. Also note that the Lily Pad has no VIN pin and accepts only a regulated input.**5V:** The regulated power supply used to power the microcontroller and other components on theboard. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.

➢ **3V3** (Diecimila-only) :A 3.3 volt supply generated by the on-board FTDI chip.

➢ **GND:**Ground pins.

Other Pins

➢ **AREF:**Reference voltage for the analog inputs. Used with analog reference().

➢ **Reset:** (Diecimila-only) Bring this line LOW to reset the microcontroller. Typically used to add areset button to shields which block the one on the board.

3.4 . DC MOTORS

Almost every mechanical movement that we see around us is accomplished by an electric motor. Electric machines are a means of converting energy. Motors take electrical energy and produce mechanical energy. Electric motors are used to power hundreds of devices we use in everyday life. Motors come in various sizes. Huge motors that can take loads of 1000's of Horsepower are typically used in the industry. Some examples of large motor applications include elevators, electric trains, hoists, and heavy metal rolling mills.

Examples of small motor applications include motors used in automobiles, robots, hand power tools and food blenders. Micro-machines are electric machines with parts the size of red blood cells, and find many applications in medicine. Electric motors are broadly classified into two different categories: DC (Direct Current) and AC (Alternating Current). Within these categories are numerous types, each offering unique abilities that suit them well for specific applications.

In most cases, regardless of type, electric motors consist of a stator (stationary field) and a rotor (the rotating field or armature) and operate through the interaction of magnetic flux and electric current to produce rotational speed and torque. DC motors are distinguished by their ability to operate from direct current. There are different kinds of D.C. motors, but they all work on the same principles. In this chapter, we will study their basic principle of operation and their characteristics. It's important to understand motor characteristics so we can choose the right one for our application requirement. The learning objectives for this chapter are listed below.

Electromechanical Energy Conversion

An electromechanical energy conversion device is essentially a medium of transfer between an input side and an output side. Three electrical machines (DC, induction and synchronous) are used extensively for electromechanical energy conversion. Electromechanical energy conversion occurs when there is a change in magnetic flux linking a coil, associated with mechanical motion. Electric Motor The input is electrical energy (from the supply source), and the output is mechanical energy (to the load).

The input is electrical energy (from the supply source), and the output is mechanical energy (to the load).

Electrical energy	Electromechanical energy conversion device	Mechanical energy
Source	Motor	Load
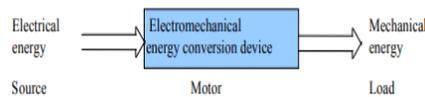
Fig 3.5 Block diagram of Electromechanical energy conversion

Construction

DC motors consist of one set of coils, called armature winding, inside another set of coils or a set of permanent magnets, called the stator. Applying a voltage to the coils produces a torque in the armature, resulting in motion.

Stator

The stator is the stationary outside part of a motor

.● The stator of a permanent magnet dc motor is composed of two or more permanent magnet pole pieces.

● The magnetic field can alternatively be created by an electromagnet. In this case, a DC coil (field● winding) is wound around a magnetic material that forms part of the stator.

Rotor

● The rotor is the inner part which rotates

.● The rotor is composed of windings (called armature windings) which are connected to the external●circuit through a mechanical commutator.

● Both stator and rotor are made of ferromagnetic materials. The two are separated by air-gap
● Winding A winding is made up of series or parallel connection of coils. Armature winding - The winding through which the voltage is applied or induced.
● Field winding - The winding through which a current is passed to produce flux (for the electromagnet)
● Windings are usually made of copper.

DC Motor Basic Principles
Energy Conversion

If electrical energy is supplied to a conductor lying perpendicular to a magnetic field, the interaction of current flowing in the conductor and the magnetic field will produce mechanical force (and therefore, mechanical energy).

Value of Mechanical Force

There are two conditions which are necessary to produce a force on the conductor. The conductor must be carrying current, and must be within a magnetic field. When these two conditions exist, a force will be applied to the conductor, which will attempt to move the conductor in a direction perpendicular to the magnetic field. This is the basic theory by which all DC motors operate.

The force exerted upon the conductor can be expressed as follows.

F = B i l Newton (1)

 where B is the density of the magnetic field, l is the length of conductor, and i the value of current flowing in the conductor. The direction of motion can be found using Fleming's Left Hand Rule.
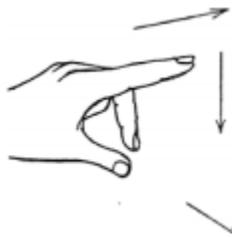

Fig 3.6 Fleming's Left Hand Rule

The first finger points in the direction of the magnetic field (first - field), which goes from the North pole to the South pole. The second finger points in the direction of the current in the wire (second - current). The thumb then points in the direction the wire is thrust or pushed while in the magnetic field (thumb - torque or thrust).

Principle of operation

Consider a coil in a magnetic field of flux density B (figure 4). When the two ends of the coil are connected across a DC voltage source, current I flows through it. A force is exerted on the coil as a result of the interaction of magnetic field and electric current. The force on the two sides of the coil is such that the coil starts to move in the direction of force.
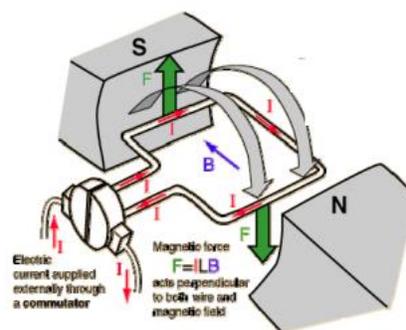
Fig 3.7 Principle of Operation of DC motor

In an actual DC motor, several such coils are wound on the rotor, all of which experience force, resulting in rotation. The greater the current in the wire, or the greater the magnetic field, the faster the wire moves because of the greater force created.

At the same time this torque is being produced, the conductors are moving in a magnetic field. At /dt) as shown inϕdifferent positions, the flux linked with it changes, which causes an emf to be induced (e = d figure 5. This voltage is in opposition to the voltage that causes current flow through the conductor and is referred to as a counter-voltage or back emf.
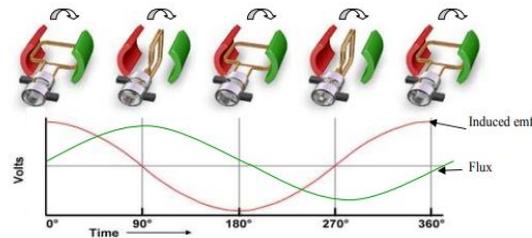
Fig 3.8 Production of alternating emfs in DC motor

The value of current flowing through the armature is dependent upon the difference between the applied voltage and this counter-voltage. The current due to this counter-voltage tends to oppose the very cause for its production according to Lenz's law. It results in the rotor slowing down. Eventually, the rotor slows just enough so that the force created by the magnetic field (F = Bil) equals the load force applied on the shaft. Then the system moves at constant velocity.

3.5 DRIVER CIRCUIT

In electronics, a driver is a circuit or component used to control another circuit or component, such as a high-power transistor, liquid crystal display (LCD), and numerous others.

They are usually used to regulate current flowing through a circuit or to control other factors such as other components, some devices in the circuit. The term is often used, for example, for a specialized integrated circuit that controls high-power switches in switched-mode power converters. An amplifier can also be considered a driver for loudspeakers, or a voltage regulator that keeps an attached component operating within a broad range of input voltages.

Typically the driver stage(s) of a circuit requires different characteristics to other circuit stages. For example in a transistor power amplifier circuit, typically the driver circuit requires current gain, often the ability to discharge the following transistor bases rapidly, and low output impedance to avoid or minimize distortion.

Fig 3.9 LM289N Driver Circuit

PROJECT DESCRIPTION

In this Project, DC motor is used for movement of Robo by using Driver Circuit LM289N. We can access the number of rotations made by DC motor can be implemented by using Arduino processor. In Arduino processor, we have implemented logic in such a way that Robo can walk and sustain in any environmental conditions.

DC motor is installed by using Driver Circuit LM289N

CONCLUSION & RESULTS

Multi Terrain Robo Project can be implemented in any environmental conditions in an efficient way. . We can access the number of rotations made by DC motor can be implemented by using Arduino processor through logic software design.

REFERENCES

[1] G. Desouza and A. Kak. Vision for mobile robot navigation: a survey. IEEE Transactions on Pattern Analysis and Machine Intelligence, 24(2):237–267, Feb. 2002.

[2] T. Huntsberger, H. Aghazarian, A. Howard, and D. C. Trotz. Stereo visionbased navigation for autonomous surface vessels. Journal of Field Robotics, 28(1):3–18, 2011.

[3] D. A. Johnson, D. J. Naffin, J. S. Puhalla, J. Sanchez, and C. K. Wellington. Development and implementation of a team of robotic tractors for autonomous peat moss harvesting. Journal of Field Robotics, 26(6-7):549–571, 2009.

[4] V. Kaznov and M. Seeman. Outdoor navigation with a spherical amphibious robot. In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2010), pages 5113–5118, Oct. 2010.

[5] K. Konolige, M. Agrawal, M. R. Blas, R. C. Bolles, B. Gerkey, J. Sol, and A. Sundaresan. Mapping, navigation, and learning for off-road traversal. Journal of Field Robotics, 26(1):88–113, 2009.

[6] M. M. Loper, N. P. Koenig, S. H. Chernova, C. V. Jones, and O. C. Jenkins. Mobile human-robot teaming with environmental tolerance. In Proceedings of the 4th ACM/IEEE international conference on Human Robot Interaction (HRI 2009), pages 157–164, New York, 2009.

[7] R. R. Murphy and S. Stover. Rescue robots for mudslides: A descriptive study of the 2005 la conchita mudslide response. Journal of Field Robotics, 25(1-2):3–16, 2008.

[8] P. Santana, J. Barata, and L. Correia. Sustainable robots for humanitarian demining. International Journal of Advanced Robotic Systems, 4(2):207–218, 2007.

[9] P. Santana, C. Candido, P. Santos, L. Almeida, L. Correia, ˆ and J. Barata. The ares robot: case study of an affordable service robot. In Proceedings of the European Robotics Symposium 2008, pages 33–42. Springer, 2008.

[10] P. Santana, L. Correia, M. Guedes, and J. Barata. Visual attention and swarm cognition towards fast and robust offroad robots. In Proceedings of the IEEE International Symposium on Industrial Electronics (ISIE 2011), pages 2255–2260, 2011

. [11] S. Shoval. Stability of a multi tracked robot traveling over steep slopes. In Proceedings of the IEEE International Conference on Robotics and Automation (ICRA 2004), volume 5, pages 4701–4706, May 2004.

[12] K. Tahboub. Intelligent human-machine interaction based on dynamic bayesian networks probabilistic intention recognition. Journal of Intelligent & Robotic Systems, 45:31–52, 2006.

[13] M. Trincavelli, M. Reggente, S. Coradeschi, A. Loutfi, H. Ishida, and A. Lilienthal. Towards environmental monitoring with mobile robots. In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2008), pages 2210–2215, Sep. 2008.

[14] D. Wooden, M. Malchano, K. Blankespoor, A. Howardy, A. Rizzi, and M. Raibert. Autonomous navigation for bigdog. In Proceedings of the IEEE International Conference on Robotics and Automation (ICRA 2010), pages 4736– 4741, May 2010.