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Published Online 25 February 2015 **Research Article**

Design and Implementation of Embedded Based Cane Robot Using Solar Power Panel for Visually Impaired People

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ABSTRACT

The paper aim is to design a smart multipurpose human assistance robotic dog that needs zero maintenance. The primary purpose of this dog is to guide the visually impaired and elderly people to some predefined destination avoiding obstacles and traffic. It is also designed to act as an advanced multipurpose human assistance and service robot that is able recognize the words spoken by the user, talk to them and take action according to the spoken voice command. Voice commands are recognized by an android smartphone and the information is transferred to the main MCU using a bluetooth serial port that runs bluetooth SPP protocol stack. The robotic dog has the ability to follow a human when commanded with voice. Touch sensitive e-skin senses human finger touch and helps answering complex user requests such as time, date and weather conditions such as light and temperature. The same can be asked using voice also. It even allows the user to set wake up alarm. A built in audio playback system can play music tracks in MP3 format. One of the music tracks is kept as the alarm tone. It also plays the role of a regular watchdog during night and barks like any normal dog if it finds any abnormal activity. During the day time it can charge itself by moving around within a given region in order to find the maximum sun light, intelligently avoiding the shaded areas, thereby freeing the user completely from maintenance issues such as battery charging. It has a head; eyes and a tail like a real dog which it uses to perform special gestures during human-robot interaction.

Keywords: Index Term-ARM Cortex-M3 Processor,Bluetooth interface,Solar panel,Capacitive touch sensor,Audio codec,Ultrasonic sensors,MP3 Players,Loudspeakers,3-axis accelerometer.

INTRODUCTION

The project aim is to design a smart multipurpose human assistance robotic dog that needs zero maintenance.[1-3] The primary purpose of this dog is to guide the visually impaired and elderly people to some predefined destination avoiding obstacles and traffic. It is also designed to act as an advanced multipurpose human assistance and service robot that is able recognize the words spoken by the user, talk to them and take action according to the spoken voice command. Voice commands are recognized by an android smartphone and the information is transferred to the main MCU using a bluetooth serial port that runs bluetooth SPP protocol stack. The robotic dog has the ability to follow a human when commanded with voice. Touch sensitive e-skin senses human finger touch and helps answering complex user requests such as time, date and weather conditions such as light and temperature. The same can be asked using voice also. It even allows the user to set wake up alarm. A built in audio playback system can play music tracks in MP3 format. One of the music tracks is kept as the alarm tone. It also plays the role of a regular watchdog during night and barks like any normal dog if it finds any abnormal activity. During the day time it can charge itself by moving around within a given region in order to find the maximum sun light, intelligently avoiding the shaded areas, thereby freeing the user completely from maintenance issues such as battery charging. It has a head; eyes and a tail like a real dog which it uses to perform special gestures during human-robot interaction.[4-8]

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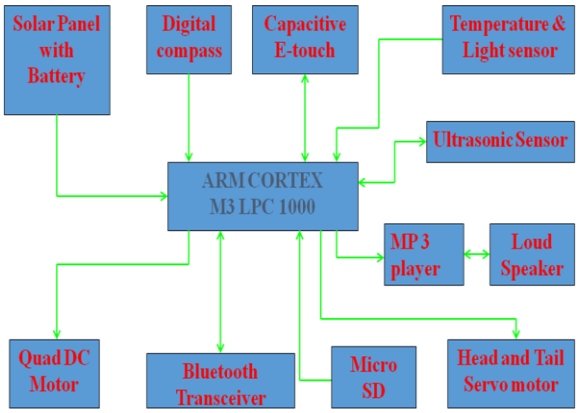
1. *Block Diagram:*



2.1.Solar Panel:

A solar panel is a set of solar photovoltaic cells modulates electricity that are connected and mounted on a supporting structure. A photovoltaic cells module is a packaged, connected assembly for solar cells. The solar panel are used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module are rated by its DC output power under standard test conditions (STC), and are typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given in the same rated output . An 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watts module. Single solar module can produce only a limited amount of power most installations contain multiple modules. Photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery or solar tracker and interconnection wiring.

2.1.2theory And Construction:

Solar modules uses light energy (photons) from the sun to generate electricity through the photovoltaic effect. The majority of modules uses wafer-based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon. Cells must also be protected from mechanical damage and moisture. Most solar modules are rigid, but semi-flexible based on thin-film cells. These early solar modules used in space in 1958.

Electrical connections are made either in series to achieve a desired output voltage nor in parallel to provide a desired current capability. Conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. The cells must be connected electrically to one another and to the rest of the system. Externally, popular terrestrial usage photovoltaic modules use MC3 (older) or MC4 connectors to facilitate easy weatherproof connections to the rest of the system.

Some recent solar module designs include concentrators in which light is focused by lenses or mirrors onto an array of smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.

2.1.3 Efficiencies:

Depending on construction, photovoltaic modules can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light). Hence much of the incident sunlight energy is wasted by solar modules, and they can give far higher efficiencies if illuminated with monochromatic light. Therefore, another design concept is to split the light into different wavelength ranges and direct the beams onto different cells tuned to those ranges. This has been projected to be capable of raising efficiency by 50%.

2.2 Classifications Of Solar Modules:

2.2.1 Crystalline silicon modules:

Most of the solar modules are currently produced from silicon photovoltaic cells. These are typically categorized as monocrystalline or polycrystalline modules.

2.2.2Thin-film modules:

Third generation solar cells are advanced thin-film cells. They are produce by a relatively high-efficiency conversion for the low cost compared to other solar technologies.

2.2.3 Rigid thin-film modules:

In rigid thin film modules, the cell and the module are manufactured in same production line.

The cell is created on a glass substrate and the electrical connections are created *in situ*, a so-called "monolithic integration". The substrate is laminated with an encapsulate to a front or back sheet, usually another sheet of glass.

The main cell technologies are categorized as CdTe, or a-Si, or a-Si+uc-Si tandem, or CIGS (or variant). Amorphous silicon has a sunlight conversion rate of 6-12%.

2.2.4 Flexible thin-film modules:

Flexible thin film cells are created on the same production line by depositing the photoactive layer and other necessary layers on a flexible substrate.

The cells are assembled into modules by laminating them into a transparent colourless fluoropolymer on the front side and a polymer suitable for bonding to the final substrate on the other side. The only commercially available flexible module uses amorphous silicon triple junction.

2. lithium-ion battery:

A lithium-ion battery is a member of a family of rechargeable battery types in which lithium ions move from the negative electrode to the positive electrode during discharge and back when they are in charging. Li-ion batteries use an intercalated lithium compound as the electrode material, compared to the metallic lithium used in non-rechargeable lithium battery.

Lithium-ion batteries are commonly used in consumer electronics. They are one of the most popular types of rechargeable battery for portable electronics, with one of the best energy densities, no memory effect , and only a slow loss of charge when they are not in use. LIBs are also growing in popularity for military, electric vehicle and aerospace applications.[22] For example, Lithium-ion batteries are becoming a common replacement for the lead acid batteries that have been used for golf carts and vehicles. Instead of having heavy lead plates and acid electrolyte, the trend is to use a lightweight lithium/carbon negative electrodes and lithium iron phosphate positive electrodes. Lithium-ion batteries can provide the same voltage as lead-acid batteries, so it are modified to drive vehicle's system is required.

3. ARM Cortex-M3 Processor:

System-on-chip solutions based on ARM embedded system processors address many different market segments including enterprise applications, automotive systems, home networking technologies. The ARM Cortex™ family processors provides us a standard architecture to address the broad performance for spectrum required by these diverse technologies. These family includes processors based on the three distinct profiles of the ARMv7 architecture. The A profile for sophisticated, high-end applications running open and complex operating systems.The R profile system are used for real time systems and the M profile for cost-sensitive and microcontroller applications.[9] This Cortex-M3 processor is the first ARM processor based on the ARMv7-M architecture and has been specifically designed to achieve the high system performance in power- and cost-sensitive embedded applications, such as microcontrollers, automotive body systems, industrial control systems and wireless networking.

4.1 Higher performance through better efficiency:

In order to achieve the higher performance, processors can either work in hard or work smart. Pushing that higher clock frequencies may increase performance but is also accompanied by higher power consumption. On the other hand, higher compute efficiency at slower clock speeds results in simpler and lower power designs that can perform the same tasks. At the heart of the Cortex-M3 processor is an advanced 3-stage pipeline core, based on the Harvard architecture, that incorporates many new powerful features like branch speculation, single cycle multiply and hardware divide to deliver an exceptional . The Cortex-M3 processor also implements the new Thumb®-2 instruction set , It helps to be 70% more efficient per MHz than an ARM7TDMI-S® processor executing Thumb instructions, and 35% more efficient than the ARM7TDMI-S processor executing ARM instructions, for the Dhrystone benchmark.

4.2 Migration from the ARM 7 processor family for better performance and power efficiency:

Over the last decade, the ARM7 family of processors has been widely adopted for many applications. The Cortex-M3 processor builds on this success to present the logical migration path for ARM7 processor-based systems. The central core offers higher efficiency; a simpler programming model and excellent deterministic interrupt behavior, whilst the integrated peripherals offer enhanced performance at low cost.

4.3 Cortex-M3 processor architecture and features:

The Cortex-M3 processor, based on the ARMv7-M architecture, has a hierarchical structure. It integrates the central processor core, called the CM3Core, with advanced system peripherals to enable integrated capabilities like interrupt control, memory protection and system debug and trace. These peripherals are highly configurable to allow the Cortex-M3 processor to address a wide range of applications and be more closely aligned with the system requirements.[10-12] The Cortex-M3 core and the integrated components have been specifically designed to meet the requirements of minimal memory implementation, reduced pin count and low power consumption.

4.3.1 The Cortex-M3 Core:

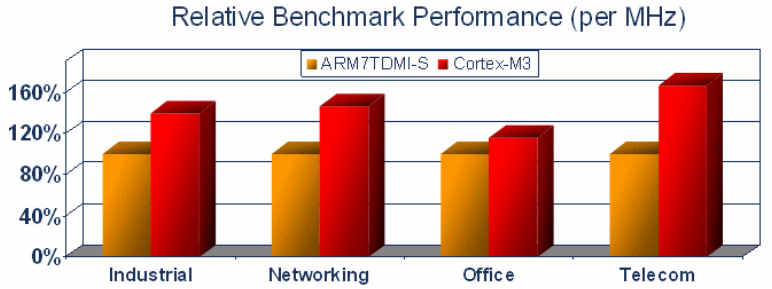
The central Cortex-M3 core is based on the Harvard architecture characterized by separate buses for instructions and data. The processor differs from the von Neumann architecture based ARM7 family of processors which use the same signal buses and memory for both instructions and data. By being able to read both an instruction and data from memory at the same time, the Cortex-M3 processor can perform many operations in parallel, speeding application execution.

3-axis accelerometer and 3-axis magnetometer LGA-28L (5x5x1.0 mm):

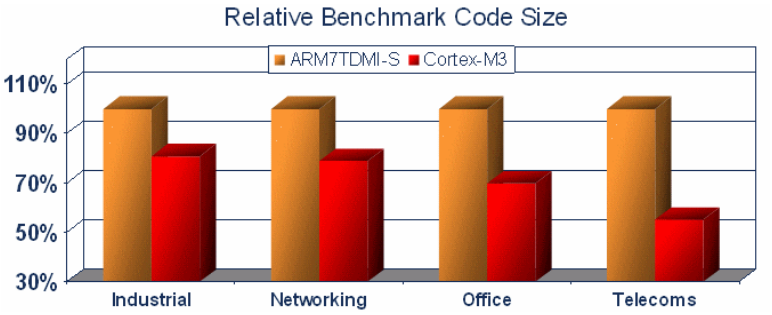
The LSM303DLH is a system-in-package featuring a 3D digital linear acceleration sensor and digital magnetic sensor. In this sensor the various sensing elements are manufactured using specialized micromachining processes,[15] The LSM303DLH includes an I2C serial bus interface that supports standard mode (100 kHz) and fast mode (400 kHz). The internal self-test capability allows the user to check the functioning of the whole module application. The system can be configured to generate an interrupt signal as well as by the position of the device itself .Then the Thresholds and timing of interrupt generators are programmable on the fly by the end user. Magnetic and accelerometer parts are additionally can be enabled or put in power-down mode separately. The LSM303DLH is available in a plastic land grid array package, are guaranteed to operate over an extended temperature range from -30 to +85 °C.

ARM7TDMI-S and Cortex-M3 comparison (100MHz frequency on TSMC 0.18G)

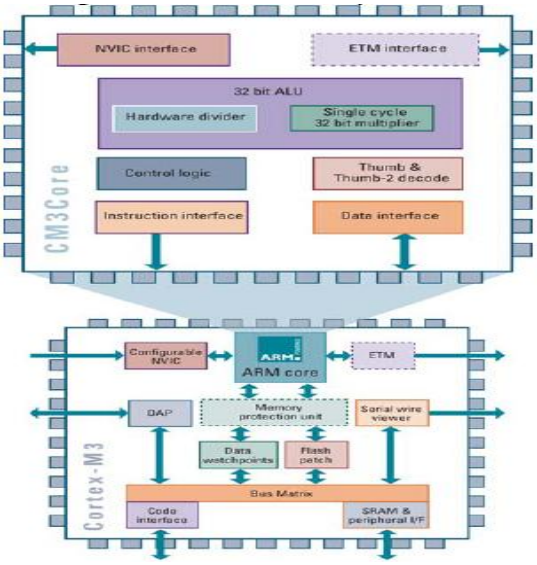
Features	ARM7TDMI-S	Cortex-M3
Architecture	ARMv4T (von Neumann)	ARMv7-M (Harvard)
ISA Support	Thumb / ARM	Thumb / Thumb-2
Pipeline	3-Stage	3-Stage + branch speculation
Interrupts	FIQ / IRQ	NMI + 1 to 240 Physical Interrupts
Interrupt Latency	24-42 Cycles	12 Cycles
Sleep Modes	None	Integrated
Memory Protection	None	8 region Memory Protection Unit
Dhrystone	0.95 DMIPS/MHz (ARM mode)	1.25 DMIPS/MHz
Power Consumption	0.28mW/MHz	0.19mW/MHz
Area	0.62mm2 (Core Only)	0.86mm2 (Core & Peripherals)*



Relative performance for ARM7TDMI-S (ARM) and Cortex-M3 (Thumb-2).

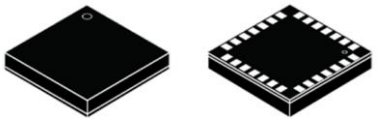


Relative code size for ARM7TDMI-S (ARM) and Cortex-M3 (Thumb-2).



The Cortex-M3 processor.

4. Agnometer And Accelerometer:



5.1 Features:

- Analog supply voltage: 2.5 V to 3.3 V
- Digital supply voltage IOs: 1.8 V
- Power-down mode
- Magnetic field channels and acceleration channels
- ±1.3 to ±8,1 gauss magnetic field full-scale
- ±2 *g*/±4 *g*/±8 *g* dynamically selectable full-scale
- 16-bit data out
- I2C serial interface
- Independent programmable interrupt generators for free-fall and motion detection
- Embedded self-test
- 6D orientation detection

Free scale's MPR121 capacitive touch sensor controller simplifies design in the user interface of choice—touch sensing. Embedded developers require design simplicity and power conservation in a small form factor for compact system designs.

Free scale's MPR121 capacitive touch sensor controller is a CMOS-based state machine that simplifies designing numerous touch applications for lighting controls, mobile phones, MP3 players, remote controls and other low-power, hand-held, electronic products. The MPR121 operates with extremely low power at 29 µA average supplies current—contained in a small, low-profile 3 x 3 x 0.65 mm 20-lead QFN package.

The MPR121 next-generation device provides 12-electrodes with increased internal intelligence such as a flexible independent calibration feature, an increased electrode count, a hardware configurable I2C address, an expanded filtering system with denounce, and completely independent electrodes with built-in auto-configuration.

5.2 MPR121 Typical Applications:

- PC peripherals
- MP3 players
- Remote controls
- Mobile phones
- Lighting controls

5. ULTRASONIC RANGING MODULE

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach upto 5mm. This modules includes that ultrasonic transmitters, receiver and control circuit.

The basic principle of work:

- Using input and output trigger for at least 10us high level signal,
- The Module automatically sends eight 40 kHz then detect whether there is a pulse signal back.
- IF the signal back, time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time*velocity of sound (340M/S) / 2

6.1Wireconnections:

Working Voltage	**DC 5 V**
Working Current	**15mA**
Working Frequency	**40Hz**
Max Range	**4m**
Min Range	**2cm**
MeasuringAngle	**15 degree**
Trigger Input Signal	**10uS TTL pulse**
Echo Output Signal	**Input TTL lever signal and the range in proportion**
Dimension	**45*20*15mm**

7.BT Interface:

BTInterface is an Android application for communicating with a micro controller device such as the Arduino, the Raspberry Pi, PIC or others. To provide control functions and much more over a Bluetooth serial connection.[13] BTInterface acts as the 'screen & buttons' to your device to select your options.

Install BTInterface on your phone and tell your friends the SMS password '1234' then they can send texts to your phone to make it speak, play sound effects, display things etc.It might be interesting to see what they come up with

Just having it set up with a terminal screen in the micro-controller Integrated Development Environment is fun. Issuing that the live commands to experiment, these commands are easily be added to the code when ready.

8. *Audio Codec:*

VS1053b is a single-chip audio decoder and IMA ADPCM encoder. It contains a high-performance, low-power proprietary DSP processor core VS DSP, working data memory, 16 KB instruction RAM and 0.5+ KB data RAM for user applications running simultaneously , upto 8 general purpose I/O pins, an UART, as well as a high-quality variable-sample rate stereo ADC and stereo DAC, this are followed by an earphone amplifier and a common voltage buffer.

VS1053b receives its input bit stream through serial input bus, which it listens to as system slave. The input stream are decoded and passed through a digital volume control to an 18-bits oversampling, multi-bit, sigma-delta DAC. The decoded is controlled via a serial control bus. In addition to that of the basic decoding, it is possible to add application features, like DSP effects, to the user RAM memory.[20]

9. *Quad DC Motor Driver:*

Dual Stepper Motor / Quad DC Motor Driver module from NEX Robotics can drive two bipolar stepper motors or 4 DC motors at the same time. In this Board it has two L298 motor driver ICs. Each motors has two H- Bridges. Board has onboard 5V low drop voltage regulator for generating the logic supply. Each motors has heat sink for

sufficient heat dissipation, free wheel diodes for protection from back EMF and current sensing resistor for current sensing. Higher current rating these H-Bridges in each motors can be connected in parallel. Board consist of 20 pin FRC connectors for logic interfacing and terminal blocks for power and motor interfacing. While in the minimal configuration only one FRC connector needs to be used. Second FRC connector are used for enhanced features such as current sensing, H-Bridge enable etc. This board is made of double sided PTH PCB for giving better strength to the connectors. LEDs are connected across each H-Bridge for easy debugging. For easier mounting the board has six mounting holes.

10. *Servo Motor:*

A Servo Motor is a motor which is part of a servomechanism. It are typically paired with some type of encoder to provide positioning and speed feedback.

A Servo Motor are also defined as an automatic device. That uses an error-correction routine to correct its motion. The term servo can be applied to a systems other than a Servo Motor systems that use the feedback mechanism such as an encoder or feedback device to control the motion parameters. When the term servo is used it applies to a 'Servo Motor' but is also used as a general control system, meaning of that a feedback loop is used to position an item.

A servomechanism may or may not be used as a servo motor. Example, a household furnace is a servomechanism that are controlled by a thermostat. Once a set temperature is reached, then there is feedback signaling it to shut off making it a "servo" in nature. The term "servo" define as the function or task.

11. *Temperature Sensors:*

The LM35 series are integrated-circuit type temperature sensors, whose output voltage is proportional to the Celsius temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in degree Kelvin, as the user is not required to subtract large constant voltage from its output to obtain convenient Centigrade . The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature. Low cost is assured by the trimming and calibration at the wafer level. The LM35's low output impedance its, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. I can be used within single power supplies, or with plus and minus supplies. As it draws only 60 µA current from its supply. It has only very low self-heating, less than 0.1°C in air . The LM35 is rated to operate over a −55° to +150°C temperature. While the LM35C is rated for a −40° to +110°C range . The LM35 series is available in hermetic TO-46 transistor , while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. LM35D is also available in 8-lead surface mount small outline package and a plastic TO-220 package.

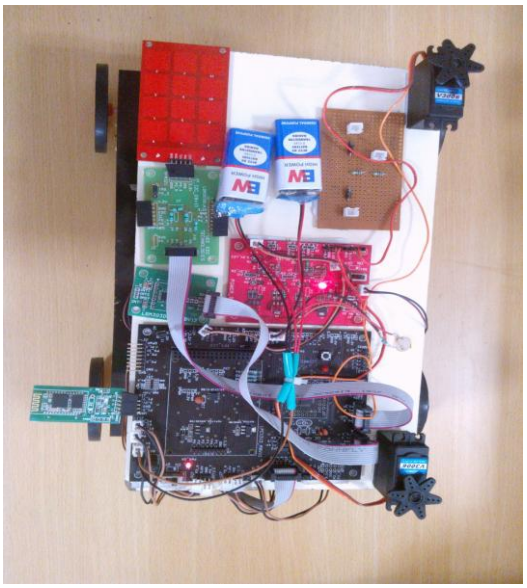
12. *Light Sensors:*

Two cadmium sulphide photoconductive cells with spectral responses that are similar to that of the human eye. This cell resistance falls within the increasing light intensity. Thus the applications include smoke detection, automatic lighting control, and counting the batch and alarm systems.

13. *Micro SD Card:*

The Twin MOS Micro SD Memory Card is functionally compatible within the SD Memory card but is small in size. It can be inserted into a passive SD or mini SD memory Card Adapter and operate as an SD Memory Card. Twin MOS Micro SD Card TM is too ideal for digital devices designed to use Micro SD Card. It is fully compatible with new consumer standard, called the Micro SD system standard and meets SDC Physical Layer specification V1.10, and provides error correcting code (ECC) reliability to detect and correct errors automatically.

Result :



Conclusion:

In this paper, a new omnidirectional-type cane robot was developed for the elderly and handicapped with zero maintenance . Motion control of this robot was studied based on online estimating human walking intention. The main contribution of this study has been to present dynamic models and online inference algorithm for the human walking intention, which is significant to lead the user's walk- inginanatural and comfortable way. An entertainment systems like MP3 player are used in this cane robot. Experiments were performed on the flat ground and slope.

It should be pointed out that the interface between the human and the robot is the multiaxis force sensor, which is expensive and fragile. To lower the cost and improve the system reliability, in the future, we would like to construct a low-cost sensing system comprising cheaper force sensors (e.g., force sensing resistors) and range finding sensors for the cane robot. By utilizing some sensor fusion approaches, the state of user can then be reliably recognized and provided to the motion controller.

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