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Wireless Control of Serpentine like Robot for Industrial Inspection and Surveillance

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Abstract*— *This paper focuses on a Robot which is biologically inspired from nature. Snakes are unique because they utilize the irregularities in the terrain and make an effective motion. This robot is designed to visualize the situation and to measure the environment parameters. Snake is composed of segments, those are individually controlled. In particular the locomotion of snake is controlled by CAN-bus. Among the all available buses the CAN-bus is faster and provides real time data transfer. A wireless technology (ZigBee) is introduced between robot section and monitoring section. The measured values are updated on the PC.

***Index Terms*— *Snake Robot, CAN-bus, locomotion control, surveillance, sensing*.**

I. INTRODUCTION

Many manmade machines are inspired from the nature. Among many available creatures around the world snakes are those whose ability to penetrating through many terrains. It will be astounding, if the features of the serpentine are pull out and confine in a robot. The movements of snake have broad characteristics gives capability to crawl in many terrains. From years of the robots development there are still many limitations in terms of locomotion and obstacle avoidance. Even the wheeled and other drive mechanisms can be traverse in all the types of terrains [1]. To create an equivalent robotic model for a snake has many complicated issues of observation. An essential issue is to understand the body motion of the snake. Normally robots with wheel and legs are more open for understanding comparing with the snake locomotion. Traditionally a wheel rotates to turn a robot and to make a movement, but in case of snake body should crawl and wriggle to provide the motion. The prototypical advantages of snake robot include terrainability, good stability and effectiveness will satisfy the requirements in many applications like inspection and surveillance [2].

Snakes have four ways of motion they are serpentine, concertina, side winding and rectilinear methods. (1) Serpentine method: Snakes will push off of any bump or other surface, rocks, trees, etc., to get going. They move in a wavy motion. They would not be able to move over slick surfaces like glass at all. This movement is also known as lateral undulation; (2) Concertina motion: This is a more difficult way for the snake to move but is effective in tight spaces. The snake braces the back portion of their body while pushing and extending the front portion. Then the snake drops the front portion of their body and straightens a pulls the back portion along. It is almost like they through themselves forward. (3) Side-winding method: It is often used by snakes to move on loose or slippery surfaces like sand or mud, in such cases the snake appears to throw its head forward and the rest of its body follows motion while the head is thrown forward again. (4) Rectilinear method: This is a slow, creeping, straight movement. The snake uses some of the wide scales on its belly to grip the ground while pushing forward with the others. These methods will create new possibilities to make things possible in many rescue applications like in disastrous, risky and perilous situations [11].

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II. SYSTEM ARCHITECTURE

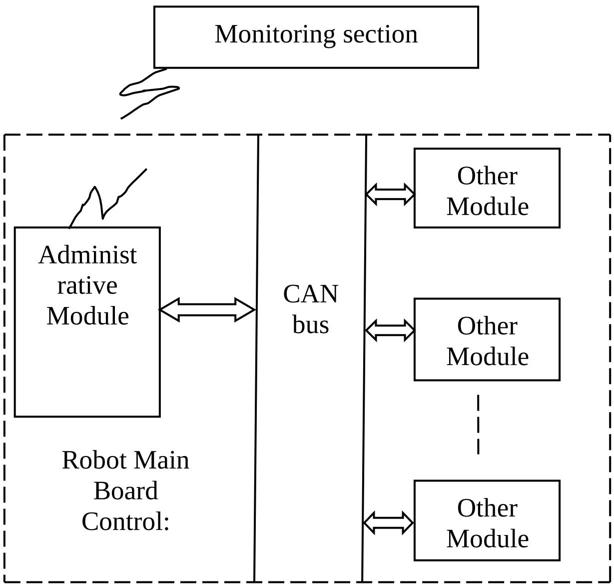

Fig.1 Over all Control of Snake Robot

Snake robot is a structure confined with segments, these segments should have a synchronized real time control, that demands the usage of CAN bus in this project [12]. There are two sections namely monitoring and robot control. Robot control section consists of controllers, sensors, and other communica- tion protocols. Monitoring sections receives the information from robot by wireless communication and sends control signals to the robot only after prompts for input.

III. ROBOT MAIN BOARD

This is the heart of the snake robot which receives commands from pc through ZigBee wireless connection and act accordingly to provide robot locomotion. The controller used in this robot is ARM 7 (LPC 2148) core which controls the motors in all segments. Sensors and others devices are attached as slave segments to this board. The master module consists of ARM7 controller, camera Sensor part, and ZigBee network modules. One module will communicate with other module through the CAN bus interface.

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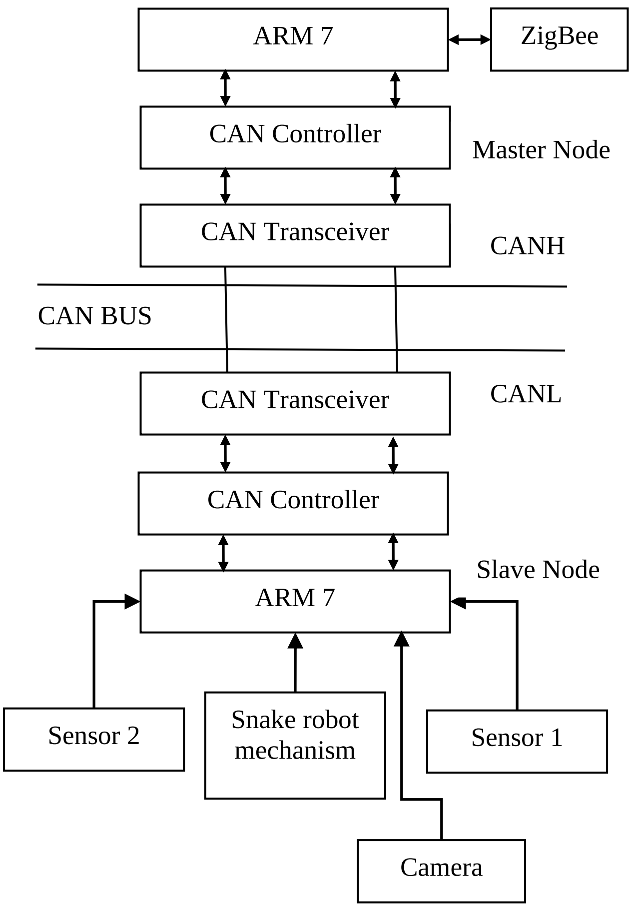

Fig.2 Main Robot Section

A. Controller

The requirements of this robot will be satisfied with the use of ARM7TDMI microcontroller and the features it provide will affect the selection of this core over the other available controllers. Various companies manufacturing these cores among them Philips LPC2148 microcontroller which has following features [13]:

It's a 32 bit microcontroller with real time emulation and embedded trace support which is facilitated with high speed flash memory of 512kb and on chip static RAM of 32kb. Hence the size of the chip is tiny and consumes less power makes this device ideal for embedded applications where size matters a lot. Various types of serial communications are possible such as USB 2.0, I^2Cs, SSP, SPI and multiple UARTs. Two 32 bit timers, 14 ten bit A/D converter channels and single 10 bit D/A converter provides variable analog output, are available to program it for several applications. Apart from these, power down modes such as idle and power down modes useful for avoiding power consumption by proper utilization of real time clock.

The functions LPC2148 in this project are (1) It has to control the sensors and other devices connected to the board; (2) The control signals are processed and communicated through CAN bus; (3) Motor movements like rotation and speed are controlled by appropriate generation of PWM signals through motor driver IC L293d.

B. Overview of CAN-bus

The Controller Area Network (the CAN bus) is a serial communications bus for real-time control applications. CAN operate at data rates of up to 1 Megabits per second and has excellent error detection and confinement capabilities. CAN was originally developed by the German company Robert Bosch for use in automobile-manufacturing industry. In the network any node can broadcast messages at any time known as "Multicast". Expanding the network, by adding other node is very flexible, which doesn't need any reconfiguring the whole system [3]. On the whole it's a confined form of a three components host processor, CAN controller and Transceiver. CAN controller is hardware with a synchronous clock. It performs (1) Receiving: the Can controller stores received bits serially from the bus until the entire message is available. (2) Sending: the processor stores it's transmit messages to a CAN controller which transmits the bits serially on to the bus. Transceiver: This is possibly integrated into the CAN controller. It performs (1) Receiving: It adapts signal levels from the bus to levels that the CAN controller operates. (2) Sending: It converts the transmit bit signal received from the CAN controller in a signal that is sent on to the bus. Data transmission through CAN bus is performed by various frames such as data frame, error frame, remote frame, overload frame. (1) Data frame: a frame containing node data for transmission; (2) Error frame: a frame transmitted by any node detecting an error; (3) Remote frame: a frame requesting the transmission of specific identifiers; (4) Overload frame: a frame to inject a delay between data and/or remote frame [7]. While in data transmission CAN protocol performs: (1) Fault confinement: an active error flag is sent to nodes upon detection of errors similarly passive error flag is transmitted to the nodes if there is no error; (2) Error detection: Can protocol defines five methods to detect errors they are, (a) Bit monitoring: Bus signals are monitored to detect the errors. The differences between the bit sent and bit received will be observed to detect the errors; (b) Bit stuffing: means after five consecutive equal bits transmitter inserts a stuff bit stream and complementary action performed at the receiver; (c) Frame check: Fixed format and frame size are verified with the transmitted frame and if error occurs frame error is activated; (d) Acknowledge check: It becomes active if the transmitter does not receive an acknowledgement; (e) Cyclic redundancy check: CRC safeguards the information in the frame by adding a frame check sequence (FCS) at the transmission end. After reception the FCS is recomputed and verifies the data, if any mismatch leads to a CRC error. (3) Message validation and framing: Converting the message to fixed format and validating the message; (4) Bus arbitration: it is a process of gaining the control over the bus, the node with a highest ID will orbited first rather than the node with the lowest ID, to do that dominant and recessive bits are used; (5) Transfer rate and Timing: In a Can network each node has its own clock, and during data transmission no clock is sent, so synchronization is done by dividing frame bits into segments as synchronization, propagation, phase 1 and phase 2 together do the continues synchronization enables the receiver to be able to properly read the messages [8].

C. Driving circuit

Robot locomotion mainly depends on motor movement and those are controlled by using driving IC L293d, which is capable of driving two motors at a time. It is a quadruple high current half-H driver, designed to provide driving current up to 1A at voltage ranges from 4.5V to 36V.

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It is a 16 pin dual in-line package integrated circuit having separate enable pins for both the motors it can drive and power supply. Internally IC is a combination of H-bridge circuits which is a collection of four switches intended to control the direction of the robot by using the PWM signals from the controller [14].

INPUT		OUTPUT
A	**EN**	**Y**
H	H	H
L	H	L
X	L	Z

H=high level, L= low level, X=irrelevant, Z=high impedance

Fig.4 Functional table of L293D

This chip contains four enable pins and each enable pin corresponds to two inputs. Based on the input values given, the device connected to this IC works accordingly. To move the robot in forward direction both the motors should run in clockwise direction, anti-clockwise for backward and to turn left, Right side motor is shuts down and vice versa.

D. ZigBee Wireless Network

It's a standards-based wireless technology which is designed to fulfill the unique needs of low-cost, low-power wireless sensor and control networks in battery powered applications. It requires very little power to operate, easy implementation and can be used almost anywhere, all these features created a wide range of market for this technology. ZigBee uses the 2.4 GHz radio frequency with maximum data rate of 250 Kbps [9].

ZigBee technology is developed by the ZigBee alliance group established in 2002, an open nonprofit organization having many number of semiconductor companies as members. ZigBee is standardized with the IEEE 802.15.4 standard as its physical and medium access protocols. ZigBee protocol uses open system interconnect (OSI) reference model. Various companies manufacturing ZigBee chips as it's a part of personal area network.

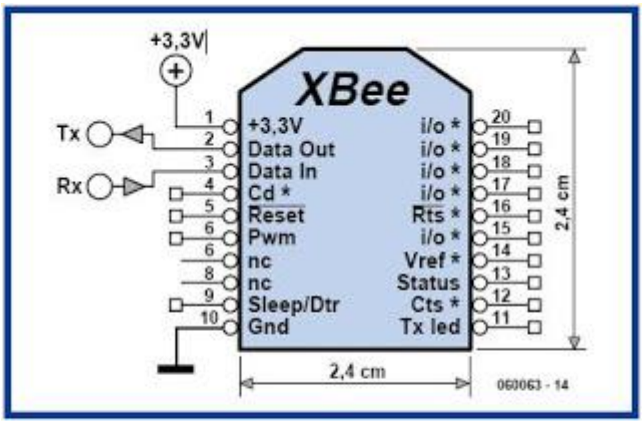

Fig.3 ZigBee/Mesh RF module

E. Sensors and Camera

As the application of this robot is inspection and surveillance which requires various sensors for inspection and camera for surveillance, are attached to the robot main board. Normally in rescue and disastrous situations it is necessary to know about the temperature, humidity levels and many other parameters, particularly this robot is equipped with temperature and humidity sensors.

LM 35 is used as temperature sensor which gives electrical output proportional to the temperature. The LM 35 is an integrated circuit temperature sensor. Humidity sensor is a device consisting of a special plastic material whose electrical characteristics change according to the amount of humidity in the air. A plug and play camera is used to visualize.

IV. MONITORING SECTION

This section controls and monitors the robot through personal computer. Monitoring section sends the control signals and receives the acknowledge signal through ZigBee technology and some of the keys of keyboard are assigned to some actions performed by the robot.

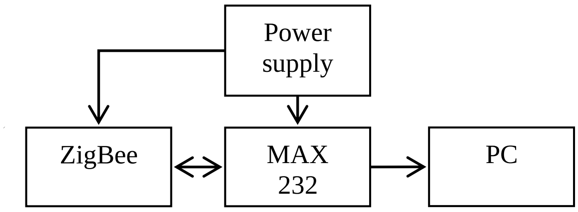

Fig.4 Structure of Monitoring Section

MAX 232 is a dual driver or receiver used to match the voltage levels of RS 232 and TTL devices. The drivers provide RS-232 voltage level outputs from a single + 5 V supply via on-chip charge pumps and external capacitors.

V. TEST RESULTS

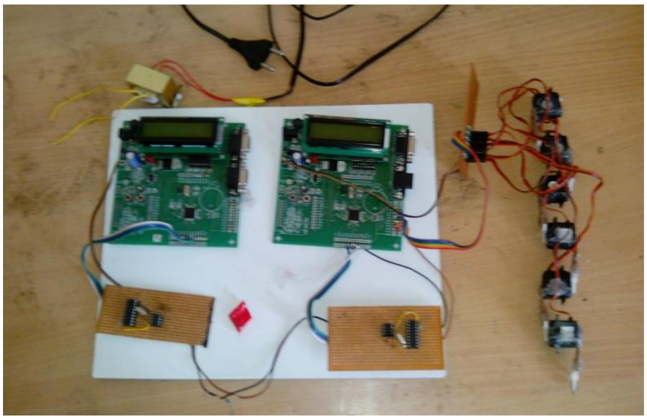

Fig.6 Serpentine of Snake-like Robot

The arrangement of snake robot using ARM7 boards is shown above. It is capable of inspecting temperature, humidity and with the use camera able to visualize the situation.

VI. CONCLUSION

In this paper a serpentine like robot is implemented which is controlled by ZigBee wireless technology and CAN bus is used between the sections of the robot for fast and real time data rates. This can extended by making robot to be to move in water and by adding more sensors to it.

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