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Design and Development of Voice/Telie Operated Intelligent Mobile Robot

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ABSTRACT
The concept of mobility, communication skills and sensing of environmental obstructions for collision avoidance have led to the development of more sophisticated machines with improved effectiveness, higher quality, reduced manpower, greater efficiency, reliability and cost effectiveness for several applications. The present submission intends to focus on three major design aspects of an intelligent vehicle such as its operation under control of IR transreceivers for improved maneuverability, tele-operation to enable remote driving in harsh and otherwise adverse situations, IR proximity sensors to provide sufficient situational awareness for collision avoidance and also on the voice commanded operations particularly for use in rehabilitation engineering. A set of codes corresponding to each operation including the opening and closing of the grippers for holding the objects are generated from the keypad and transmitted. These transmitted codes are intercepted by a FM radio receiver mounted on the vehicle, for processing by the supervisory control for required operation to be performed. The idea of proximity sensing is based on the principle of transmitting modulated IR rays from an IR LED and on applying the reflected signal from the surrounding objects to a high precision PLL based tone decoder circuitry for further processing. The voice command operation through a language independent but speaker dependent speech recognition system is performed by generating and transmitting coded signal each corresponds to one particular operation which are picked up by the same FM radio receiver for required operation. A speech synthesizer for better interaction with the users has also been incorporated.

I. Introduction

The present age of exploding science and technology has proved beyond doubts that the humankind is soon going to witness another industrial revolution, one that will involve the use and implementation of increased flexibility, intelligence and sensitivity for the realization of a robotic manipulator. The need for such manipulators has increased rapidly, particularly in industrial settings where the quest for greater productivity and tighter quality control has been paramount because of revolutionary trends in technology changing scenario and a sustained world wide growth in robotic applications. The concept of hard automation, the fore-runner of modern robotic devices, where purpose designed largely mechanical devices are built to perform a specific dedicated task 11% been1 known for the past few decades. The present day all round advances in man machine interaction have led to the development of more sophisticated computer controlled reprogrammable mechanical manipulator operatable with voice tele- command with several degree of freedom capable of being programmed to carry out one or more tasks simultaneously.

Added to the automotive concept, a new field with huge potential market for sensors has drawn attention of the engineers world-wide for installing on-board intelligence towards the: realization of Intelligent Vehicle Highway Systems (IVHS). The use of tactile sensors for automated guide way vehicle to provide a last resort indication of collision with surrounding obstructions are well known for a long time. This phenomenon is based on direct physical contact between the sensor and the object. Recent advances in electronics have significantly improved the performance and reliability and thereby increasing the number of applications by introducing proximity sensors, Particularly in harsh and otherwise adverse environments.

The present paper deals with the design, development and fabrication of one such robotic system, where the concept of 'soft automation' for robot to easily adapting to the new conditions, the design of interchangeable grippers for majority of tasks, the sensing skill for collision avoidance, better interaction and voice tele operation under harsh and unavoidable situations have been embodied.

II. System Description

The main components that constitute the system are:

- 8051 based on-board computer with 5-8 bit YO ports.
- SC-02 based speech synthesizer with amplifier.
- L293B based driver card with capability of driving 8 motors or 16 single wire controlled devices
- 2-IR optical path sensing devices.
- 6-R proximity sensing circuits using modulated IR transmission (with provision for range adjustment).
- LM567 PLL based 16 channel decoder board.
- 5519 based FM receiver for establishing remote link.
- Speech Recognition Board for voice control operation.

The system's block diagram comprising all the assembled boards as above is given in Fig. 1.

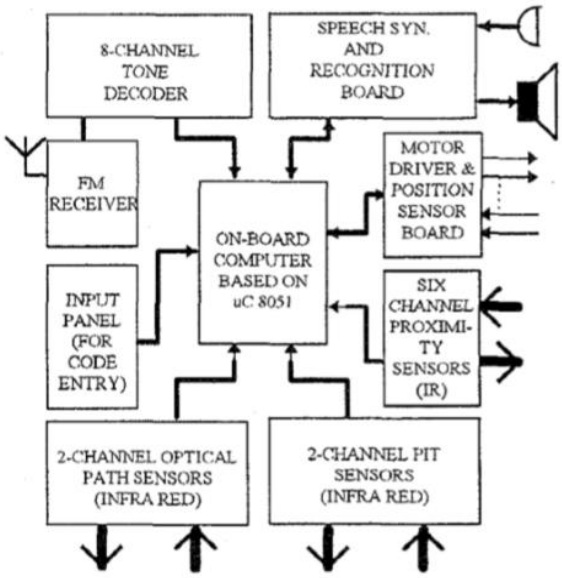


Fig. 1. System block diagram.

A number of design issues related to appropriate drive and steering configuration for a mobile robotic vehicle such as maneuverability, controllability, traction and stability apart from the modular design aspect etc. have been taken into account. The system is based on differential drive and encoders for stability and dead reckoning accuracy. The system operates on a 12 volt maintenance free rechargeable battery (12 V, 12Ali). A robot hand capable of 3 degree-of-freedom (d-0-0 uses three small sized DC servo motors with reduction gear for arm, hand and gripper movements. Contact closure tactile sensors are employed on each and every joint for avoidance of mishaps during system reset, battery down and other such mishappenings. These consists of micro switches which activated by tactile feelers attached to them. The direction of the motor movement is controlled by the polarity reversal method using H-bridges power drivers. The system can operate in four modes namely AGV mode, Remote Control mode, Voice Control mode, and Programmable mode (Teach and Play). To perform routine predefined tasks the system operate on a track under the control of IR optical path followers and for the jobs of variable nature in an open environment, the voice/tele operation mode is used. The remote operation is accomplished through a FM radio link operating at 89 MHz A vocabulary of 50 words is also provided for effective communication with the user. IR proximity sensing devices have been installed to provide intelligence for obstruction impact avoidance. An isometric sketch of the robot system is depicted in Fig. 2.

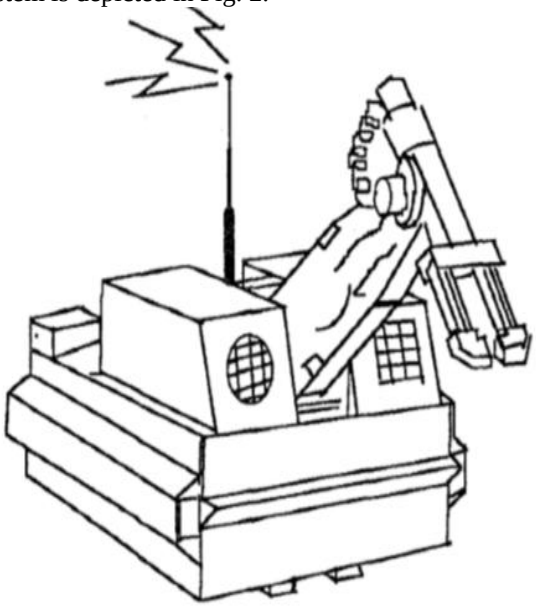


Fig. 2. Isometric sketch of robot

2.1. IR Optical Path Sensors and Proximity Sensors

The prototype optical track sensing device developed for use in the robot, is based on the concept of absorption of maximum IR radiation by black surfaces and reflection of major part by white surfaces. The IR rays emitted from IR LED are made to incident closely on a guide path consisl.ing of white and black strips. As described above the reflected IR energy from the strip is picked up by an IR photodiode, and is amplified before being fed to a comparator, whose threshold is already adjusted, according to the surface characteristics (Fig. 3). TTL logic obtained from the comparator is processed by microcontroller for the required operation. The robot is forced to move only on the guide path under the

control of correction software subroutines as and when it drifts away from the track.

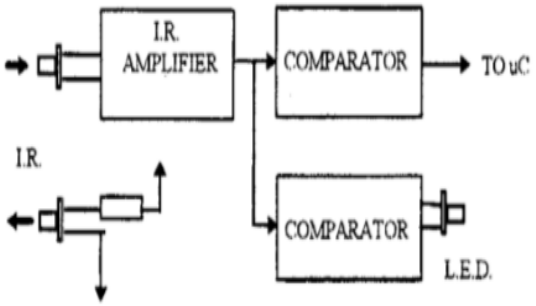
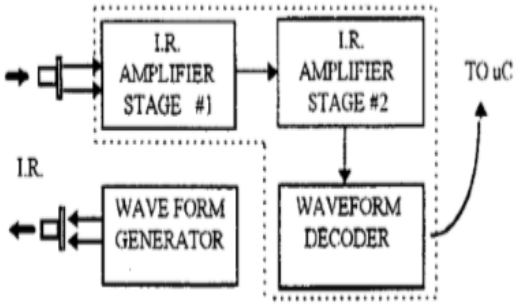


Fig. 3. IR optical path sensors.

The proximity sensing adds intelligence to the vehicle in order to provide advance warning on sensing of an obstruction in close proximity to the sensing device, thus allowing the maneuverability even in unstructured environments. The IR proximity sensing is based on the principle of transmitting modulated IR rays from a waveform generator and receiving the rays back on reflection from the surroundings by an IR photodiode. The received signal is amplified and decoded by the waveform decoder (synchronized with the waveform generator) to produce a logical output to be fed to the microcontroller for required operation to be performed. The processing includes advanced algorithms for changing its preprogramined path for obstacle avoidance and afterwards retaining its original route. The schematic is shown in Fig. 4.



Fig, 4. IR proximity sensors.

2.2. Voice/Tele Operation

A voice recognition unit built around a high speed processor ensures various operations of the system to be performed by voice command. A few of the commands recommended for operation are listed as: START, STOP, FORWARD, REVERSE, RIGHT, LEFT, SLOW, FAST, OK, UP. DOWN, CLOCK, ANTICLOCK, CLOSE, and OPEN. The speech recognition unit is based on the principle of extracting the acoustic features from a microphone captured preprocessed signal using a sixteen channel filter bank analyzer in the frequency range of 200Hz to 7000Hz. A .Frame of sixteen channel data is acquired after every 5ins by data acquisition chip. The processor checks for the overloaded signals and store them after intensity normalization provided it is different from the previous sample. The effect of speaking rate variations was minimized using the Dynamic Time Warping (DTW) techniques. To speed up the DTW computation and rejection of alien words, the rejection thresholds have been used. Each recognized word generates an S-bit coded data, which is transferred to the encoder.

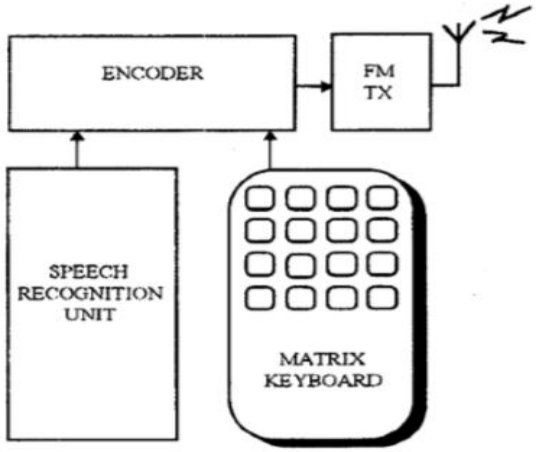


Fig. 5. Voice/Tele operation

When it is controlled by a handy 4s4 matrix keypad, a similar set of codes is generated and transferred to the encoder. The encoder circuit receives the outputted codes either from the speech recognition unit or keypad (Fig. 5.) and converts them into a set of frequencies. Each frequency corresponds to a particular task to be carried out at the manipulator end and are transmitted using an FM transmitter.

2.3. Tone Decoder

The signal transmitted from the FM transmitter as described above are intercepted by a FM radio receiver and is connected to a chain of sixteen channel PLL based high precision tone decoder circuit after suitable amplification (Fig. 6.). Decoders are tuned to same set of frequencies as generated from the encoder on the transmission end. On acquiring and matching the intercepted signal the decoder generates an 8 bit code for microcontroller for further processing.

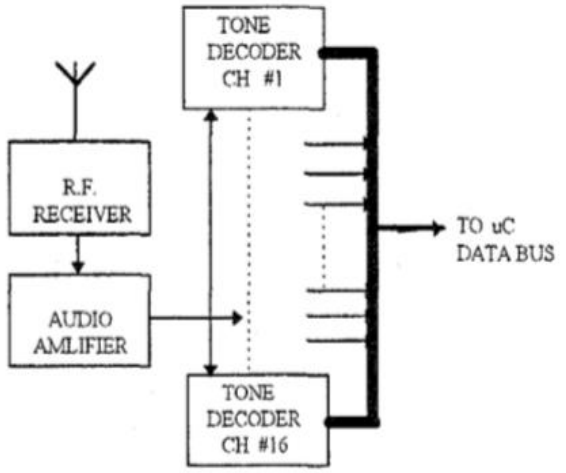


Fig. 6. Receiver and tone decoder.

2.4. Speech Synthesis Unit

A phoneme based speech synthesizer, SC-02 has been used to produce an audio output of unlimited vocabulary of words and sound effects at an extremely low data input rate. Speech is synthesized by combining phonemes and the building blocks of speech in an appropriate sequence. To improve the mechanical sound of the synthesizer to sound more like natural speech, the phonological variation, phonetic variation, variation in pronunciation, phoneme duration, allophone inventory and effect of surrounding context etc. have been controlled by the variation of appropriate acoustic parameters after a certain period of time. These are: speech rate, pitch, pitch movement rate, amplitude, articulation rate, vocal tract filter response, vocal tract filter movement rate, and phoneme duration etc. Tuning of the glottal source which is needed to be tuned from time to time has also been controlled.

2.5. Driving Scheme and Motor Driver Board

An indoor propulsion system incorporating two independently controlled center wheel differential drive has been implemented enabling the robot to spin in place about a vertical axis for maneuvering in congested areas. Drive motor velocities and positions are monitored through optical encoders attached to the armature shafts. Incremental optical encoders (single channel tachometer encoder) which basically is a instrumented mechanical light chopper giving square pulses for further evaluation, forms a cost effective position and velocity tracking device. All motors are suitably geared and operated in closed loop configuration. Power control of all the motors is through a highly efficient power module which uses four quad-half-H-bridge drivers (4 x L293) controlling a total of 8 DC motors (Fig. 7.).

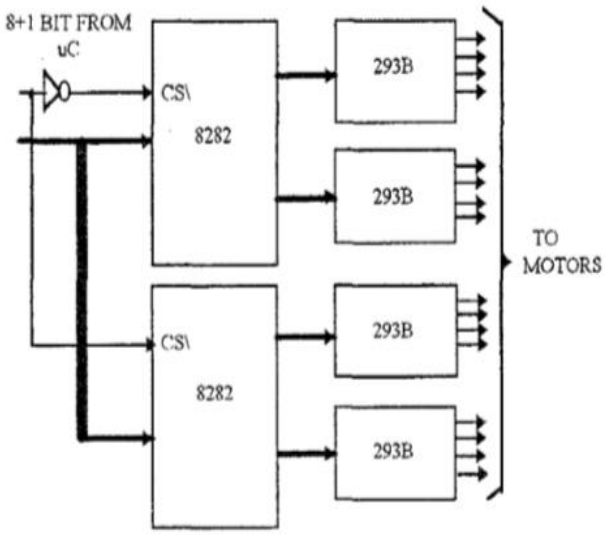


Fig. 7. Motor driver board.

III. Conclusion

A highly reliable and versatile system to accomplish a purpose design specific task such as distribution of medicine and food to the bed ridden patients specially in infected and inaccessible areas of the hospitals and medical centers have been reported. The on-board intelligence helps providing situational awareness a basic requirement of the system to be operated by voice/tele command for ascertaining a majority of other tasks in open loop environment. The operation by voice command could best be used for handicapped.

IV. Acknowledgement

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