TRACKING LIMB MOTION USING INERTIAL MEASUREMENT UNITS (IMU)

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Abstract - *The system is provided with highly accurate human body motion capture and interactive three-dimensional by combining low cost MEMS inertial measurement units (IMU).It presents the development of a low cost wireless real-time inertial limb tracking system for virtual training. 9 Degrees of Freedom (DOF) Inertial Measurement Units (IMU) is used for tracking and sensing motion of any platform and is an ideal sensor system for motion control of aerial autonomous systems like multi-rotors, model airplanes, helicopters etc., and other systems that require to control the pitch, roll and yaw. The 9DOF Razor IMU incorporates three sensors - an ITG-3200 (MEMS triple-axis gyro), ADXL345 (triple-axis accelerometer), and HMC5883L (triple-axis magnetometer) - to give nine degrees of inertial measurement .The IMU sensors are placed on user's body and limbs according to human skeletal action, and each sensor performs 9 degrees of freedom (DOF) tracking at a high-speed update rate. Secondly, the collected sensor data are transferred through Microcontroller. The inner communication between the Multipoint Control Unit (MCU) and the Inertial Measurement Unit (IMU) is through Inter-Integrated Circuit (I^2C). Finally The Inertial Measurement Units (IMU) sensor values are serially connected with Mat lab based PC Program for Motion detection.*

Key Words: **— IMU, MEMS, Degrees Of Freedom, inertial limb tracking, Inter-Integrated circuit, IR Sensor, Multi point Control Unit.**

1.INTRODUCTION

The main idea is to accomplish the development of a low cost wireless real-time inertial limb tracking system for virtual training, which will make the Artificial limb to get the movement as normal leg motion, therefore affected humans can walk like a normal human and they can overcome the feel that they are handicapped. The rehabilitation of the motion in limb muscle plays the major role in Inertial Measurement Units. The monitoring of any rehabilitation program is desirable to ensure the correct execution of the exercise by the patient and also to quantify the progress toward the recovery of muscle strength, endurance, and increase in the range of motion. Hip abduction/adduction, hip and knee extension are among the most popular and most effective rehabilitation exercises for improving lower-limb muscle function and treating. Even when exercises are performed under supervision, often clinicians and physiotherapists use only visual, and thus subjective, observations of the human's movement.

The system is designed to provide highly accurate human body motion capture and interactive three-dimensional by combining low cost MEMS inertial measurement units (IMUs).The 9DOF Razor IMU incorporates three sensors - an ITG-3200 (MEMS triple-axis gyro), ADXL345 (triple-axis accelerometer), and HMC5883L (triple-axis magnetometer) - to give nine degrees of inertial measurement. The gyroscope and accelerometer provide information about accelerations in all three directions, and rotations around each axis. Gravity provides a background direction from the accelerometer, so short term movements can be tracked. However, in order to track the real position and orientation in space, the six-axis sensor is not quite efficient because small errors build up in each axis and over the time these errors can add up to a drift in the absolute direction. We can deal with this problem by adding one more. Absolute directional sensor called 3-axis magnetometer. The extra magnetic field information allows the sensing algorithms to compensate for small drifts over Much longer periods of time, so there is a very good chance of tracking the absolute change in position and orientation much more accurately and the location during complex movements can be measured and tracked precisely.

1.2 Existing system

In the existing system, the usage of MEMS sensor will provide only 3-axis propagation, which is comfortable for human walking movements. The microcontroller used is Arduino board which posses high power consumption. Kinect sensor provides accuracy but it is more expensive.

The RF transmitter will transmit the data which contains noise that leads to inaccurate data calculation.

2. SYSTEM DESCRIPTION

2.1 IMU sensor:

The IMU is one of the units in electronics module which collects angular velocity and linear acceleration data which is sent to the main processor. The IMU actually contains two separate sensors. The first sensor is the accelerometer triad which generates three analog signals describing the accelerations along each of its axes produced by, and acting on the object. Due to threshold range system and physical limitations, the most significant of these sensed accelerations is caused by gravity. The second sensor is the angular rate sensor triad. It also outputs three analog signals. These signals describe the angular rate about each of the sensor axes. Even though the IMU is not located at center of object mass, the angular rate measurements are not affected by linear or angular accelerations. The data from these sensors are collected by the IMU 6811 microprocessor by a 12 bit ADC board. The sensor information is then returned to the main processor through RS422 serial communications interface at a rate of about 200 Hz. The accelerometer triad, and angular rate sensors within the IMU are mounted such that their sensor coordinate axes are not aligned with those of the objects. This is due to the fact that the two sensors in the IMU are mounted in two different orientations in the object, along with the fact that the axes of the IMU are not aligned with the object axes.

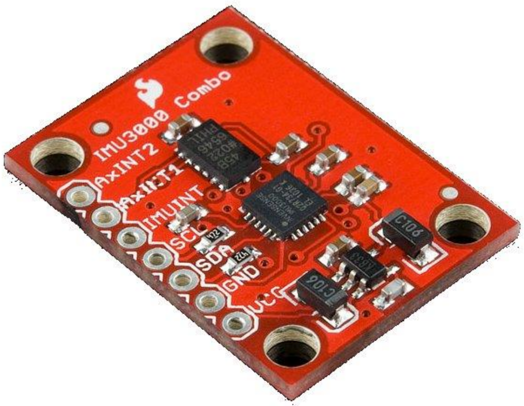

Fig -1: IMU SENSOR

2.2 .ZIGBEE module:

The main applications with 802.15.4 are aimed at control and monitoring applications where relatively low levels of data throughput are needed. Remote, battery powered sensors, low power consumption is a key requirement, also sensors, lighting controls, security and many more applications will play major role in new technologies.

North America is allowed to operate in one of the three license free bands at 2.4 GHz, 915 MHz for and 868 MHz for Europe. In this way the standard is able to operate around the globe, there will be deviations in specifications for each and every bands are slightly different. At 2.4 GHz there are a total of sixteen different channels available, and the maximum data rate is 250 kbps. For 915 MHz there are ten channels and the standard supports a maximum data rate at 40 kbps, while at 868 MHz there is only one channel and this can support data transfer at up to 20 kbps.

The modulation techniques also vary according to the band which is in use. Direct sequence spread spectrum is used at any cases. However for the 868 and 915 MHz bands are the correct form modulation which is binary phase shift keying. For the 2.4 GHz band, offset quadrature phase shift keying is employed.

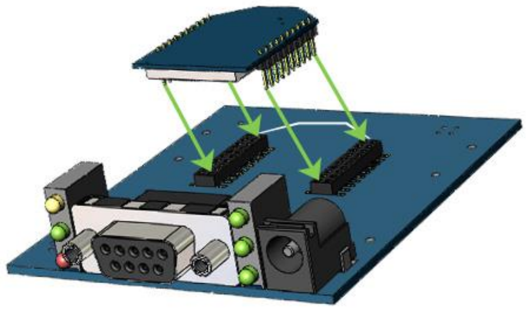

Fig -2: ZIGBEE MODULE

2.3 MICOCONTROLLER:

The ARM7 includes ARM7TDMI, ARM7TDMI-S, ARM720T, and ARM7EJ-S processors. The ARM7TDMI is the core processor in industry's most widely used 32-bit embedded RISC microprocessor solution. ARM7 has Optimization of cost and power-sensitive applications, the ARM7TDMI solution provides the low power consumption, small size, and high performance needed in portable, embedded applications.

The ARM7TDMI core uses a three-stage pipeline which will increase the flow of instructions to the processor. Therefore providing the features to allows multiple simultaneous operations to take place and continuous operation in the processor and memory systems. The ARM7TDMI memory interface has optimum performance potential and minimized memory usage. Speed critical control signals are pipelined to allow system control will function the exploit fast-burst access modes supported by many memory technologies.

There is an option to make use either a single bidirectional data bus or two separate unidirectional data input and output buses. The ARM7TDMI can be configured to treat stored words in either big-endian or little-endian format.

Performance, code density and operating states

The ARM instruction set allows a program to achieve maximum performance with the minimum number of instructions. The simpler thumb instruction set will offer much increased code density reducing memory requirement. Code can switch between the ARM and thumb instruction sets on any procedure call.

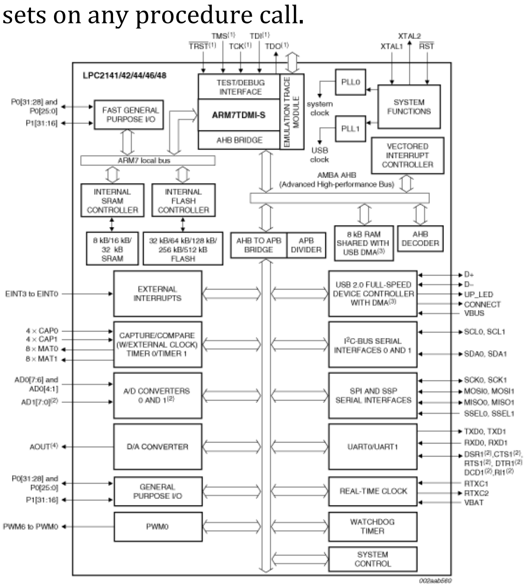

Fig -3: ZIGBEE MODULE

2.4 ARCHITECTURE DIAGRAM:

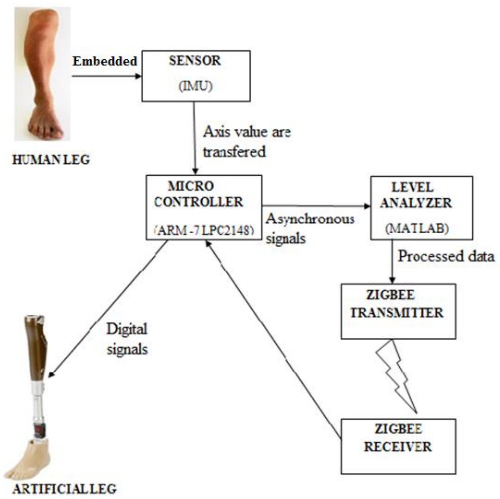

Fig -4: ARCHITECTURE DIAGRAM

In this transmitter section, the IMU sensor is connected to the arm microcontroller the values that are capture from the original leg is transferred to the ARM microcontroller through the inter-integrated circuit(I2C).I2C is used for serial communication .The arm microcontroller processes the captured values and transmit it to the level analyzer through the UART .the arm microcontroller transmits the asynchronous data through the UART Ports to the level analyzer where the matlab coding takes place. the level analyzer is used to analyze the values with the motion captured data .hence after analyzing these captured data ,the data is to be send to the zibgee .

In the reception module ,the values from the zigbee module at the transmitter side is received to the another zigbee at the receiver end.the values that are received are transmitted to the ARM microcontroller at the reciever end.this microcontroller converts the analog signals to digital signals to rn the mechanical setup. The last and the final stage is that the transmitter modle and the reception module are integrated throug the two zigbees at the transmitter and the reciever end.hence there is a wireless medium between them.

2.5 BLOCK DIAGRAM:

TRANSMITTER SECTION:

This is the transmitter section which includes IMU sensor, ARM LPC 2148, level analyzer, uart and zigbee transmitter.

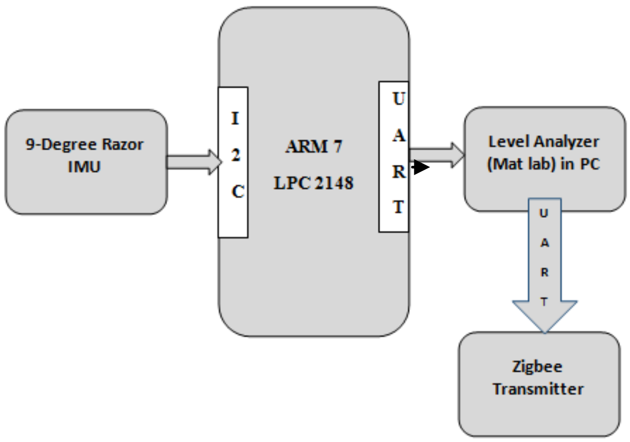

Fig -4: TRANSMITTER SECTION

RECEIVER SECTION:

The receiver section will include zigbee receiver, ARM LPC 2148, PWM, and mechanical setup which ia fixed in the artificial leg

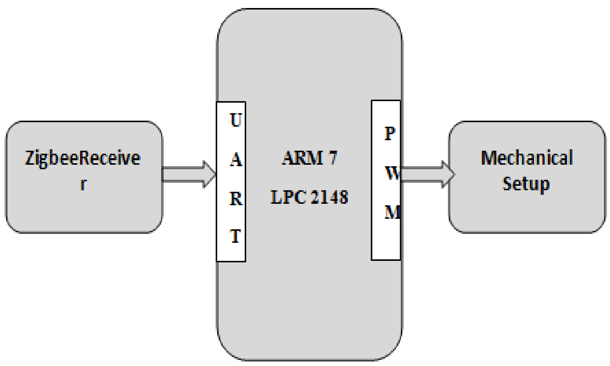

Fig -4: RECEIVER SECTION

2.5. EXPERIMENT SETUP:

The system specification is a technical specification of requirements for the software products. It is the first step in the requirements analysis process and list the requirements of a particular software system which includes functional, performance and security requirements. The requirements also provide usage scenarios from an user , and an administrative perspective .The software requirements specification purposes to provide a detailed overview of the software project, its parameters and goals. This describes the project target audience and its user interface, hardware and software requirements.

One of the unique advantage of this project is that, it establishes real time low cost wireless inertial tracking limb motion .The limb tracking motion is done by the IMU sensor which captures the motion of human leg which the sensor is fixed with . The experimental setup consists of the microcontroller, which is the central control of the experiment. ARM LPC 2148 microcontroller is connected with the sensors to get the input from the human beings in the form of axis values and this sensor input pass through the microcontroller and gets in to the disabled leg through zigbee module .Level analysis is the main function which will analyze the range direction and axis rotation which are from the IMU sensor and activates the motion in the challenged leg accordingly. This data is collected from IMU sensor and then given as input to the Matlab for processing level analysis**.**

2.6. EXPERIMENT RESULT :

On implementing this system the physically challenged person can able to walk like normal human beings, hence they come out of the feel that they are physically challenged. IMU sensor and ARM LPC 2148 plays major role in motion capture and processing accurate values which implement the whole system to work.

CONCLUSIONS

On implementing this system the physically challenged person can able to walk like normal human beings, hence they come out of the feel that they are physically challenged. IMU sensor and ARM LPC 2148 plays major role in motion capture and processing accurate values which implement the whole system to work.

REFERENCES

[1] Vincent Bonnet, Vladimir Joukov, Dana Kuli´ c, *Member, IE EE*, Philippe Fraisse, *Member, IEEE*,NacimRamdani, and Gentiane Venture, *Member, IEEE "Monitoring of Hip and Knee Joint Angles Using a Single Inertial Measurement Unit During Lower Limb Rehabilitation*", IEEE Sensors journal, vol. 16, no. 6, march 15, 2016,Paris, France.

[2] Vincent Bonnet and Gentiane Venture "*Fast Determination of the Planar Body SegmentInertial Parameters Using Affordable Sensors*",IEEE Transactions on neural systems and rehabilitation engineering, vol. 23, no. 4, July 2015,Italy.

[3] Dongyu Yuan, Xiaochuan Ma, Yu Liu, Zhigang Shang, and Shefeng Yan, *Senior Member, IEEE* , "*Statistical Modeling of Random Walk Errors for Triaxle Rate Gyros*", IEEE transactions on instrumentation and measurement, vol. 65, no. 2, February 2016,China.

[4]Zheming Wu, *Student Member, IEEE*, Zhenguo Sun, *Member, IEEE*, Wenzeng Zhang and Qiang Chen, "*A Novel Approach for Attitude Estimation Basedon MEMS Inertial Sensors using Nonlinear ComplementaryFilters*",IEEE ensorsJournal,2016, japan.

[5]Tri-Nhut Do, Ran Liu, Chau Yuen Senior Member, IEEE, and U-Xuan Tan*, Member, IEEE, "*Personal Dead Reckoning using IMU mounted on upper Torso and inverted Pendulum Model",* IEEE SENSORS JOURNAL, 2016,Germany.

[6]Yang Zhang1, Yunfeng Fei2, Lin Xu1*, and Guangyi Sun1† "micro-IMU-Based Motion Tracking System for Virtual Training"1. Institute of Robotics and Automatic Information System, Nankai University Tianjin Key Laboratory of Intelligent Robotics, Tianjin, China

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