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An Accelerometer-Based Digital Pen with a Trajectory Recognition Algorithm for Handwritten Digit and Gesture Recognition

M.Annie Priyadarshini
M.Tech Student,
Dept of ECE.
Institute of Aeronautical Engineering,
Dundigal, Quthbullapur, Hyderabad,
Telangana, India.

B.Naresh
Assistant Professor,
Dept of ECE.
Institute of Aeronautical Engineering,
Dundigal, Quthbullapur, Hyderabad,
Telangana, India.

ABSTRACT:

Now a day, the growth of miniaturization technologies in electronic circuits and components has greatly decreased the dimension and weight of consumer electronic products, such as smart phones and handheld computers, and thus made them more handy and convenient. This paper presents an accelerometer-based digital pen for handwritten digit and gesture trajectory recognition applications with robot movement by using MEMS sensor. The digital pen consists of a triaxial accelerometer, a microcontroller, and a Zigbee wireless transmission module for sensing and collecting accelerations of handwriting and gesture trajectories.

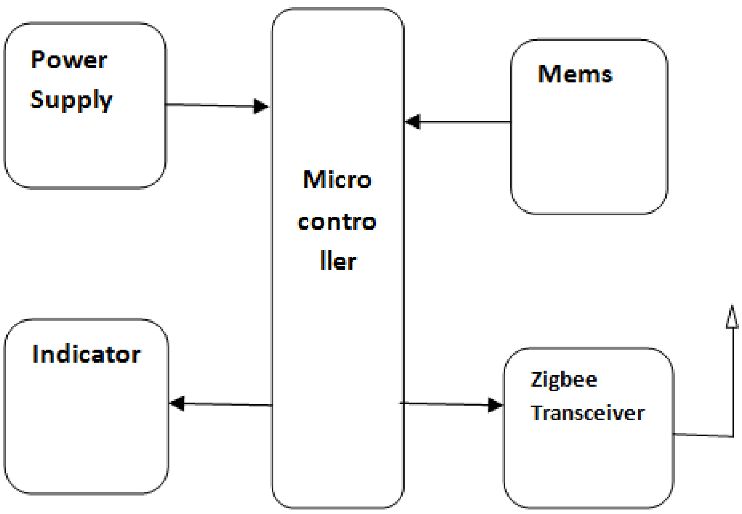
Using this project we can do human computer interaction.Users can use the pen to write digits or make hand gestures, and the accelerations of hand motions measured by the accelerometer are wirelessly transmitted to a computer for online trajectory recognition. So, by changing the position of mems (microelectro mechanical systems) we can able to show the alphabetical characters in the PC. The acceleration signals measured from the triaxial accelerometer are transmitted to a computer via the wireless module.

Keywords: ARM, Zigbee, Sensors module.

I .INTRODUCTION

BLOCK DIAGRAM:

Pen section:



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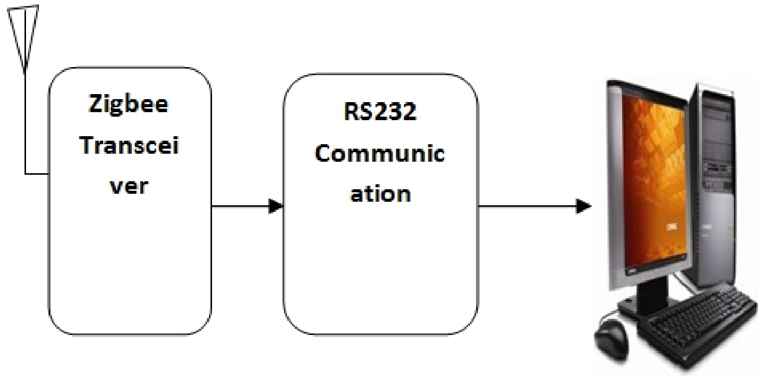
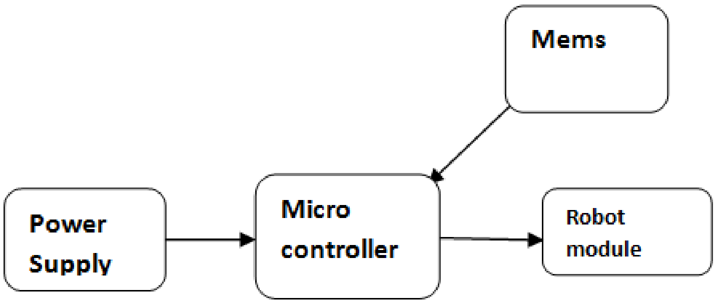
Pc Section:





II. MICROCONTROLLER (ARM9) FAMILY:

The LPC2926/2927/2929 combine an ARM968E-S CPU core with two integrated TCM blocks operating at frequencies of up to 125 MHz, Full-speed USB 2.0 OTG and device controller, CAN and LIN, 56 kb SRAM, up to 768 kb flash memory, external memory interface, three 10-bit ADCs, and multiple serial and parallel interfaces in a single chip targeted at consumer, industrial and communication markets. To optimize system power consumption, the LPC2926/2927/2929 has a very flexible Clock Generation Unit (CGU) that provides dynamic clock gating and scaling.

Features and benefits:

ARM968E-S processor running at frequencies of up to 125 MHz maximum. Multi-layer AHB system bus at 125 MHz with four separate layers.

On-chip memory:

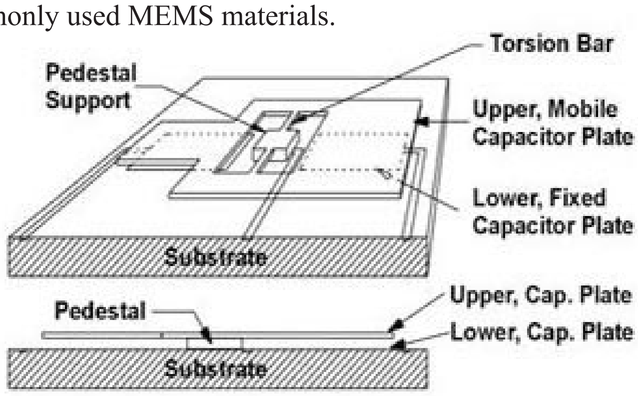
•Two Tightly Coupled Memories (TCM), 32 kB Instruction TCM (ITCM), 32 kB Data,
TCM (DTCM).
• Two separate internal Static RAM (SRAM) instances; 32 kB SRAM and 16 kB SRAM.
•8 kB ETB SRAM also available for code execution and data.
•Up to 768 kB high-speed flash-program memory.
•16 kB true EEPROM, byte-erasable and programmable.

Dual-master, eight-channel GPDMA controller on the AHB multi-layer matrix which can be used with the Serial Peripheral Interface (SPI) interfaces and the UARTs, as well as for memory-to-memory transfers including the TCM memories. External Static Memory Controller (SMC) with eight memory banks; up to 32-bit data bus; up to 24-bit address bus. Serial interfaces:

•USB 2.0 full-speed device/OTG controller with dedicated DMA controller and on-chip device PHY.
•Two-channel CAN controller supporting Full CAN and extensive message filtering.
•Two LIN master controllers with full hardware support for LIN communication. The LIN interface can be configured as UART to provide two additional UART interfaces.
•Two 550 UARTs with 16-byte Tx and Rx FIFO depths, DMA support, and RS485/EIA-485 (9-bit) support.
•Three full-duplex Q-SPIs with four slave-select lines; 16 bits wide; 8 locations deep; Tx FIFO and Rx FIFO.
•Two I2C-bus interfaces.

III. MEMS Technology:

Micro-Electro-Mechanical Systems (MEMS) is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate through micro fabrication technology.MEMS is an enabling technology allowing the development of smart products, augmenting the computational ability of microelectronics. In most cases, the physics behind the behavior of MEMS devices can be expressed by mathematical expressions. MEMSolver works by creating a mathematical model of the system and generates analytical solutions to explain the behavior of the MEMS device. The user just has to enter the input parameters like length and width of the beam for example in a user friendly GUI, and the software will immediately calculate the relevant results and plot graphs that fully explain the MEMS device or part of it. The software is divided into five modules namely mechanics, sensing, actuation, and process and data analysis. Mechanics module is subdivided into three sub sections. The first subsection being structures where the most commonly used beams and diaphragm designs are examined. The second subsection discusses vibration of these structures, both free and forced vibrations. The third subsection discusses damping in the form of squeeze film and slide film damping. Sensing module discusses sensing schemes widely used in MEMS namely piezoresistive and capacitive sensing for designing pressure sensors and accelerometers. Actuation module examines the two widely used means of actuation namely electrostatic and thermal applied to some commonly used actuators like parallel plate, micro mirror, comb drive, bimetallic and bimorph actuators. Process module is divided into six subsections namely lithography, oxidation, diffusion, implantation, film deposition and wet etching. This covers some of the most commonly used processes used in the development of MEMS devices. The data analysis module has a die calculator, unit conversion tool and lists the material properties of commonly used MEMS materials.



The increasing demand for MEMS (micro-electromechanical systems) technology is coming from diverse industries such as automotive, space and consumer electronics. MEMS promises to revolutionize nearly every product category by bringing together silicon-based microelectronics with micromachining technology, making possible the realization of complete systems-on-a-chip. KLA-Tenor offers the tools and techniques, first developed for the integrated circuit industry, for this emerging market.Micro-electro-mechanical systems (MEMS) technology has contributed to the improved performance, reliability and lower-cost sensors that support basic automobile functions within the automotive industry. MEMS technology is expected to play an important role in the future of Research And Development of automotive industry particularly in the active safety area. MEMS sensors have the following advantages: they are deterioration-free and are durable for long periods; they have good dynamic characteristics, superior impact resistance, low power consumption, low cost, they are small in size, and easy for installation.

MEMS are considered to be as a key technology with potential to meet the requirements of the Intelligent Transportation Technology (ITS). MEMS sensors used in automotive systems etc. usually comprise micro beams and inertial mass formed by etching part of aSilicon substrate, and piezo-resistors formed as strain gauges on the beams. Applications of MEMS sensors are not limited to airbag systems. They are also used in vehicle motion control systems, for example in the Antilock Braking System (ABS). Crash sensors can detect and calculate crash parameters such as velocity and acceleration. Existing technologies for active safety are being modified using MEMS sensors to enhance the performance of current systems; such as airbags or belt pre-tension devices. These systems reduce the risk of injury and its level during a crash which motivates the development of Intelligent Safety Systems (ISS). These mechanisms work on the principle of large deflecting arcs and the beams and achieve motion by the deflection of their members. Prescribed motion profiles can be obtained more easily using buckling members in compliant mechanism design. If these mechanism's members were rigid the mechanism would have zero degree of freedom.

IV. TRAJECTORY ALGORITHM:

A trajectory is the path that a moving object follows through space as a function of time.

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A trajectory is a sequence $(f^k(x))_{k\in\mathbb{N}}$ of values calculated by the iterated application of a mapping f to an element x of its source.

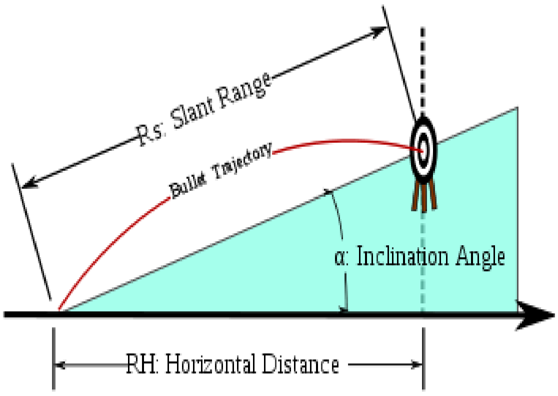

Illustration showing the trajectory of a bullet fired at an uphill target.

Physics of trajectories:

Consider a particle of mass , moving in a potential field . Physically speaking mass represents inertia, and the field represents external forces, of a particular kind known as "conservative". That is, given at every relevant position, there is a way to infer the associated force that would act at that position, say from gravity. Not all forces can be expressed in this way, however.The motion of the particle is described by the second-order differential equation

$$m\frac{\mathrm{d}^2\vec{x}(t)}{\mathrm{d}t^2} = -\nabla V(\vec{x}(t))$$ With

$$\vec{x} = (x, y, z)$$

Uniform gravity, no drag or wind

Let g be the acceleration. Relative to the flat terrain let the initial horizontal speed be $v_h = v\cos(\theta)$ and the initial vertical speed is $v_v = v\sin(\theta)$. It will also be shown that, the range is $2v_h v_v/g$, and the maximum altitude is $v_v^2/2g$; the maximum range, for a given initial speed v, is obtained when $v_h = v_v$, i.e. the initial angle is 45 degrees. This range is v^2/g, and the maximum altitude at the maximum range is a quarter of that.

Derivation of the equation of motion:

Assume the motion of the projectile is being measured from a Free fall frame which happens to be at (x, y) = (0, 0) at t=0. The equation of motion of the projectile in this frame (by the principle of equivalence) would be $y = x\tan(\theta)$. The co-ordinates of this free-fall frame, with respect to our inertial frame would be $y = -gt^2/2$. That is, $y = -g(x/v_h)^2/2$.

Now translating back to the inertial frame the co-ordinates of the projectile becomes

$y = x\tan(\theta) - g(x/v_h)^2/2$ That is:

$$y = -\frac{g\sec^2\theta}{2v_0^2}x^2 + x\tan\theta$$,

(Where v_0 is the initial velocity, θ is the angle of elevation, and g is the acceleration due to gravity).

Range and height [edit]

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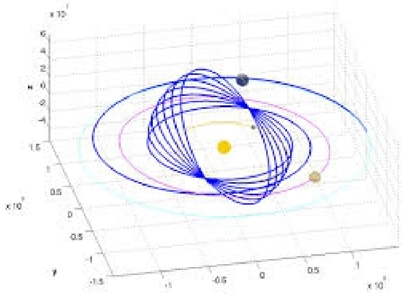


Trajectories of projectiles launched at different elevation angles but the same speed of 10 m/s in a vacuum and uniform downward gravity field of 10 m/s2. Points are at 0.05 s intervals and length of their tails is linearly proportional to their speed. t = time from launch, T = time of flight, R = range and H = highest point of trajectory (indicated with arrows).The range, R, is the greatest distance the object travels along thex-axis in the I sector. The initial velocity, vi, is the speed at which said object is launched from the point of origin. The initial angle, θi, is the angle at which said object is released. The g is the respective gravitational pull on the object within a null-medium.

$$R = \frac{v_i^2 \sin 2\theta_i}{g}$$

The height, h, is the greatest parabolic height said object reaches within its trajectory

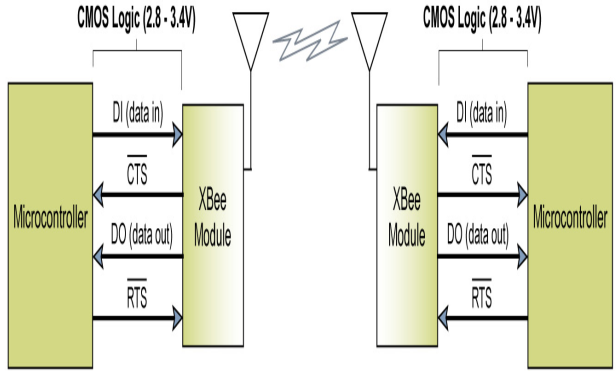
$$h = \frac{v_i^2 \sin^2 \theta_i}{2g}$$

V. WIRELESS COMMUNICATION:
Zigbee module:

The XBee/XBee-PRO RF Modules are designed to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices. The modules operate within the ISM 2.4 GHz frequency band and are compatible with the following:

- XBee RS-232 Adapter
- XBee RS-232 PH (Power Harvester) Adapter
- XBee RS-485 Adapter
- XBee Analog I/O Adapter
- XBee Digital I/O Adapter
- XBee Sensor Adapter
- XBee USB Adapter
- XStick
- Connect Port X Gateways
- XBee Wall Router.

The XBee/XBee-PRO ZB firmware release can be installed on XBee modules. This firmware is compatible with the ZigBee 2007 specification, while the ZNet 2.5 firmware is based on Ember's proprietary designed for ZigBee" mesh stack (EmberZNet 2.5). ZB and ZNet 2.5 firmware are similar in nature, but not over-the-air compatible. Devices running ZNet 2.5 firmware cannot talk to devices running the ZB firmware.



VII.CONCLUSION:

This paper presents an accelerometer-based digital pen for handwritten digit and gesture trajectory recognition applications. The digital pen consists of a triaxial accelerometer, a microcontroller, and a Zigbee wireless transmission module for sensing and collecting accelerations of handwriting and gesture trajectories.Using this project we can do human computer interaction.

VIII.REFERENCES:

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Student Profile:

M. Annie Priyadarshini pursuing M.Tech in Institute of Aeronautical Engineering, Dundigal, Telangana, India.She pursued her B.Tech from DRK Institute of Science and Technology, Bowrampet, R.R district.

Guide Profile:

B.Naresh is working as Assistant professor in ECE Dept, Institute of Aeronautical Engineering, Dundigal, Telangana, India. He pursued M.Tech from JNTU University, Hyderabad.