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Optimization of Robotic Exoskeleton with Ameliorated Stability System

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Abstract - The robotic exoskeletons of the past are manually controlled and physically balanced mechatronic devices, facilitating mobility of the leg impaired patients. The human brain enables involuntary weight balancing and body stabilization with instantaneous reflex mechanisms. The weight balancing with actuation of exoskeleton is a challenging task to users with extreme condition of leg disorders. The optimization of exoskeleton using accelerometer and gyroscope system for stability control will be a great step to improve and ease the usage for exoskeletons.

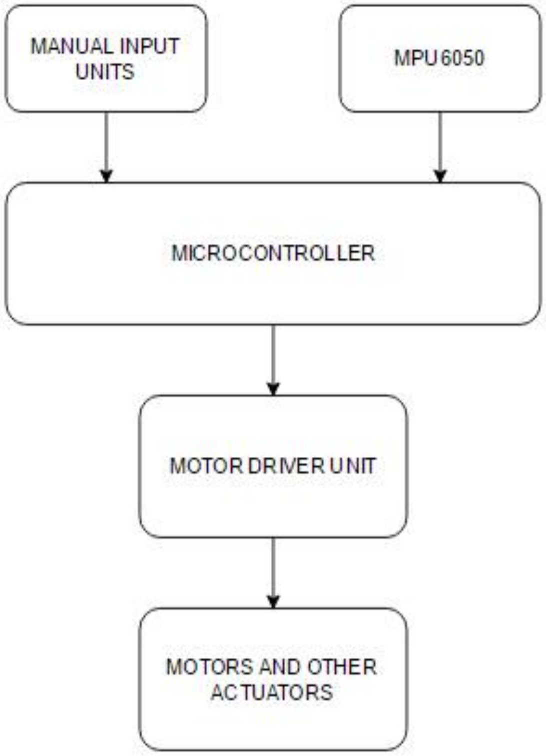
Keywords - Robotics, Exoskeleton, Accelerometer, Stabilization.

I. INTRODUCTION

The exoskeletons for leg impaired patients are the ultimate hope to get back on legs with optimum support and balance. The exoskeletons in the usage of patients at present, demand high effort and training. This reduces the comfort and impact of such an incredible technological innovation. With the present research and technological innovation, the exoskeletons can be facilitated with systems to perform in an intelligent and stabilized manner. The implementation accelerometer and gyroscope based system to analyze the instantaneous stability of the exoskeleton will be a optimal solution to enhance the stability of exoskeleton. The control of motors and joint actuation units in the system can be implemented by the analysis of the stability data.

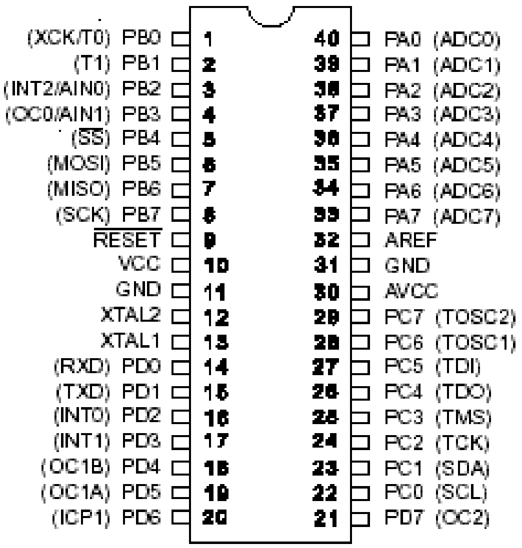
II. PROPOSED IDEA

The exoskeleton stability system is designed with systematic analysis of accelerometer and gyroscope axis values and shift in axial data over time. The implementation of this system is done by interfacing an MPU6050 three axis accelerometer and gyroscope module with atmega16 microcontroller. The motor control unit are connected to the microcontroller as output peripherals. The exoskeleton navigation is generally controlled by manual input of the user. Thus, the system takes manual input , accelerometer and gyroscope data to establish stability analysis and output as motor control.



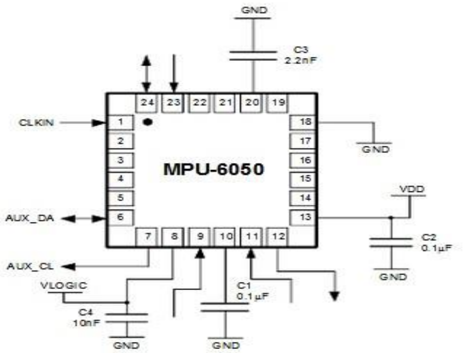
III. MICROCONTROLLER – ATMEGA16

ATMEGA 16 is a 8-bit microcontroller of high performance with low power consumption. The microcontroller is a enhanced system based on the concept of reduced instruction set computing architecture. The set of instructions to the microcontroller are executed in one cycle. The microcontroller is designed based on the clock speed of 16MHz. Atmega 16 is designed with 16KB programmable flash memory, 1KB of static RAM and EERPROM of 512 Bytes. The flash memory and EEPROM are designed with endurance cycle 10,000 and 100,000 respectively. The input/output channel is divided into four ports with total of 32 I/O lines. The microcontroller is designed with various in-built peripherals like USART, ADC, Analog Comparator, SPI, JTAG. The ADC concept is implemented with 8 channel ADC I/0 lines. The ADC is designed with 10 bit resolution. The AREF(pin 32) sets the reference voltage for the analog to digital conversion in the microcontroller. The ADC0-ADC7 pins function as the ADC peripheral for the microcontroller.



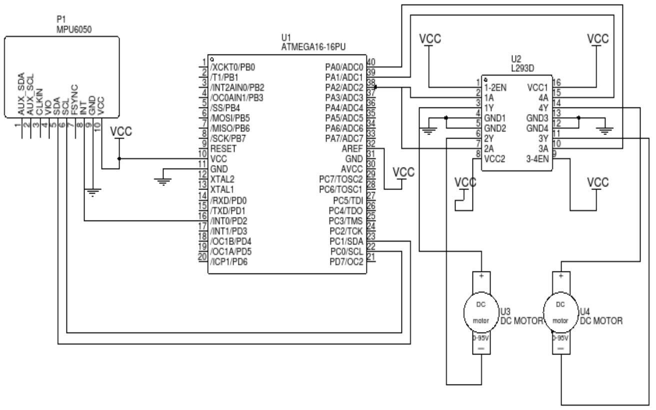
IV. MPU6050 – ACCELEROMETER AND GYROSCOPE UNIT

The MPU6050 is motion tracking device using accelerometer, gyroscope and digital motion processing units. MPU6050 is designed with 3-axis gyroscope, 3-axis accelerometer on the same silicon die together with digital motion processing implementation to analyze the motion data. The MPU6050 is used widely as user-friendly modules for the ease of developers. The MPU6050 module is designed with 8 connection pins. The pins are VCC, GND, SCL, SDA, XDA, XCL, AD0 and INT. The SDA and SCL pins are used to retrieve the motion based information from the MPU6050, to the microcontroller unit.



V. ELECTRONIC CIRCUIT DESIGN

The electronic circuit is established using ATMEGA16, MPU6050, L293D and DC motors. The DC motors are used to establish the change in actuation and movements based on the stability analysis. The SDA and SCL of MPU6050 are connected to the pin 22 and pin 23 of the microcontroller. The INT pin of the MPU6050 is connected to the interrupt pin (pin 16) of the microcontroller. The four input pins of the L293D are connected to the PA0, PA1, PA2 and PA3. The circuit is designed to establish the body stabilization using DC motors, based on the accelerometer and gyroscope data.



VI. MICROCONTROLLER REGISTER INITIATION

The microcontroller ATMEGA16 has dedicated registers to implement various input, output, analog to digital and various other peripheral functions. The I^{2}C registers of ATMEGA16 are initialized and set at optimum data setting to establish optimum performance. The dedicated registers for the input and output ports are registered to establish the input and output functions. The input and output ports are set in appropriate modes using data direction registers (DDRX), pin registers (PINX) and port registers(PORTX).The DDRX, PORTX and PINX registers are 8-bit registers. The DDRX registers are used to set the pin as input or output mode pins. The PINX registers are used to read the values in a particular pin. The PORTX registers are used to write the values in a particular pin.

VII. STABILITY ANALYSIS

The stability system is implemented using the MPU6065 module. The accelerometer and gyroscope coordinates are used to determine the change in body coordinates during the movement. The stability of the robot with implementation of this system determines the performance of motion balance and ease of user . The placement of MPU6050 in torso of a body, will enable perfect analysis of body balance.

The tilt and coordinate shift data is utilized in the following way, let us consider the following variables in standing posture,

x_1 = Standard upright body accelerometer x-coordinates.

y_1 = Standard upright body accelerometer y-coordinates.

z_1 = Standard upright body accelerometer z-coordinates.

x_2 = Current body position accelerometer x-coordinates.

y_2 = Current body position accelerometer y-coordinates.

z_2 = Current body position accelerometer z-coordinates.

α_1 = Standard upright body position gyroscope α- coordinates.

β_1 = Standard upright body position gyroscope β- coordinates.

μ_1 = Standard upright body position gyroscope μ - coordinates.

α_2 = Current body position gyroscope α - coordinates.

β_2 = Current body position gyroscope β - coordinates.

μ_2 =Current body position gyroscope μ - coordinates.

T = Preset Time interval between positions 1 and 2.

$\Delta x=x_2-x_1$; $\Delta y=y_2-y_1$; $\Delta z=z_2-z_1$

$\Delta \alpha = \alpha_2- \alpha_1$; $\Delta \beta = \beta_2- \beta_1$; $\Delta \mu = \mu_2- \mu_1$

ΔXcritical = Critical change in accelerometer x-coordinate.

ΔYcritical = Critical change in accelerometer y-coordinate.

ΔZcritical = Critical change in accelerometer z-coordinate.

αcritical = Critical change in gyroscope α – coordinates.

βcritical = Critical change in gyroscope β - coordinates.

μcritical = Critical change in gyroscope μ - coordinates.

Tcritical = Critical time of stability

The exoskeleton system is stable if,

$(\Delta x,\ \Delta y,\ \Delta z)_T < (\Delta X\text{critical},\ \Delta Y\text{critical},\ \Delta Z\text{critical})_{T\text{critical}}$, $T > T\text{critical}$ and

$(\Delta\alpha, \Delta\beta, \Delta\mu)_T < (\Delta\alpha\text{critical}, \Delta\beta\text{critical}, \Delta\mu\text{critical})_{T\text{critical}}$

The change in accelerometer coordinates of the system is less than the critical change in accelerometer coordinates. The time interval for observed change in coordinates is more than the critical time of stability. The change in gyroscope coordinates of the system is less than the critical change in gyroscope coordinates.

The exoskeleton system is not stable if,

$(\Delta x,\ \Delta y,\ \Delta z)_T > (\Delta X\text{critical},\ \Delta Y\text{critical},\ \Delta Z\text{critical})_{T\text{critical}}$, $T < T\text{critical}$ and

$(\Delta\alpha, \Delta\beta, \Delta\mu)_T > (\Delta\alpha\text{critical}, \Delta\beta\text{critical}, \Delta\mu\text{critical})_{T\text{critical}}$

The change in accelerometer coordinates of the system is more than the critical change in accelerometer coordinates. The time interval for observed change in coordinates is less than the critical time of stability. The change in gyroscope coordinates of the system is more than the critical change in gyroscope coordinates.

The exoskeleton system is not stable in linear perspective if,

$(\Delta x,\ \Delta y,\ \Delta z)_T > (\Delta X\text{critical},\ \Delta Y\text{critical},\ \Delta Z\text{critical})_{T\text{critical}}$, $T < T\text{critical}$ and

$(\Delta\alpha, \Delta\beta, \Delta\mu)_T < (\Delta\alpha\text{critical}, \Delta\beta\text{critical}, \Delta\mu\text{critical})_{T\text{critical}}$

The change in accelerometer coordinates of the system is more than the critical change in accelerometer coordinates. The time interval for observed change in coordinates is less than the critical time of stability. The change in gyroscope coordinates of the system is less than the critical change in gyroscope coordinates.

The exoskeleton system is not stable in angular perspective if,

$(\Delta x,\ \Delta y,\ \Delta z)_T < (\Delta X\text{critical},\ \Delta Y\text{critical},\ \Delta Z\text{critical})_{T\text{critical}}$, $T < T\text{critical}$ and

$(\Delta\alpha, \Delta\beta, \Delta\mu)_T > (\Delta\alpha\text{critical}, \Delta\beta\text{critical}, \Delta\mu\text{critical})_{T\text{critical}}$

The change in accelerometer coordinates of the system is less than the critical change in accelerometer coordinates. The time interval for observed change in coordinates is less than the critical time of stability. The change in gyroscope coordinates of the system is more than the critical change in gyroscope coordinates.

The correction signal of stability system is sent to microprocessor for instantaneous response, to retain the stability of the exoskeleton. The end effectors are actuated in such a way to establish the positive/negative correction factor for negative/positive error in stability analysis results.

VIII. CONCLUSION

The stabilization system for robotic exoskeleton for leg impairment, is an promising concept to improve the existing exoskeletons. The implementation of this stabilization system will enhance the ease of training and movement of patients with extreme immobile conditions. The quick decision making and response of the system, will ensure the safety and continuous effort the patients.

REFERENCES

[1] Boris Jobbágyl , Dušan Šimšík , Jiří Marek , Ján Karchňák ,Daniela Onofrejová, 'Robotic Exoskeleton for Rehabilitation of the Upper Limb', American Journal of Mechanical Engineering, 2014, Vol. 2, pp. 299-302.

[2] Luis Manuel Vaca Benitez, Marc Tabie,Niels Will, Steffen Schmidt, Mathias Jordan, and Elsa Andrea Kirchner, 'Exoskeleton Technology in Rehabilitation: Towards an EMG-Based Orthosis System for Upper Limb Neuromotor Rehabilitation', Journal of Robotics, 2013.

[3] Saguto Dey, Souvik Halder, M.P.Nandakumar, 'Gyroscopic Stabilisation of two-dimensional gimbals platform using fuzzy logic control', International Journal of Electrical, Electronics and Data Communication, 2014, Volume-2, Issue-8.

[4] Habib Ali, 'Bionic Exoskeleton: History, Development and the Future', IOSR Journal of Mechanical and Civil Engineering, 2014, pp 58-62