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DigiKitt Productionz

The HexKitt

Final Written Report | Josh Du

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Abstract

The purpose of this project is to create a six legged hexapod that would contain features of a walking robot and a wheeled robot. This robot is called "HexKitt". HexKitt will serve as one's personal pat. This pat does not require food or litter box. All he need is periodic charging. He is designed with six legs to allow movements in tight or uneven spaces. In addition, HexKitt has wheels allow faster movements and low clearance spaces. During daylight, it roams around and avoids obstacles like an animal pat. It will act intelligently to obstacles. At night, It will roll on wheels allow faster travel speed.

Executive Summary

Hexkitt, a six-legged hexapod, was created for a person that does not have time to take care pets, but wanted pets. Hexkitt is capable of walking like a pat and reacting to patting action. When you have your hand over HexKitt, it will tile the body toward the ground where your hand is covered. During normal daylight, the Hexkitt will randomly walk around and let you pat him. During night or dark light, Hexkitt will lower its body and start driving with the built in wheels that's installed underneath. Wheels allow Hexkitt to move in a faster speed and allow battery saving.

The sonars that are installed in the front act as his eye in the environments. It will avoid run into things, and avoid knock over things. Hexkitt is equipped with fuzzy logic for obstacle avoidance. This feature enables a smooth translation between turns and forward. Once an object is detected close enough to the front of Hexkitt, he will begin rotate or walk sideways depended on the distance detected.

Hexkitt is also equipped with six ambient light sensors. This allow Hexkitt know what is the surrounding lighting level. When Hexkitt starts up, He will take a sample of six sensors' reading. The average of the readings will become the environment lighting setting. When one or more of the sensor reading is below half of the environment lighting setting, Hexkitt will lower that part of the body to simulate patting action.

Hexkitt is also equipped with six temperature sensors. Same as the light sensor, the average value of the six temperature sensors' reading represent the environment temperature. When one of the sensor is heated up to 5 degrees Celsius, Hexkitt will try to move quickly away from that heat source.

The LED bar installed inside of the body resemble the star feature of KITT(Knight Industry Three Thousand). This LED bar will represent the mood of HexKitt.

A major component of Hexkitt is the walking scheme. All six legs is controlled simultaneously with a SSC-32 Servo controller. The PVR board is doing all the calculation with inverse kinematics. Once that calculation is done, the angle of each joint and speed of the movement is sent to the servo controller. Hexkitt is current capable doing a wave gaits, tripod gaits, and a ripple gaits.

Introduction

A personal pat is always welcome for any household. He will bring joys to the family. When you own an animal pat, many problems will interrupt your busy life. You need feed the pat couples time a day, and clean litter box periodically. The pat might not follow your orders. All of these problems can be solved with one solution, HexKitt. HexKitt is automatous robot that will act like a pat, move like a pat, love you like a pat without have you to clean out the litter box, and feed him.

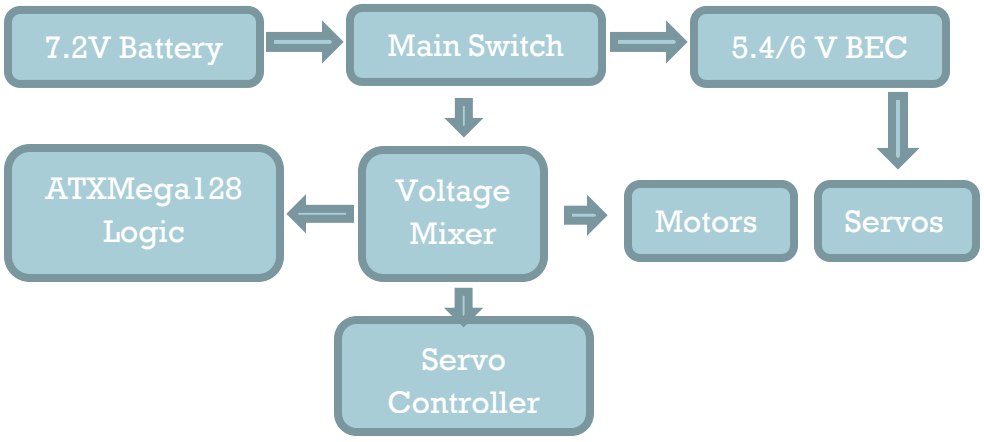
HexKitt is designed with six legs and a pair of wheels. This enables HexKitt to have more flexibility in different terrain. He can either choose to walk over uneven surface or low level obstacles. He can also put the wheels down and roll under a low clearance obstacle or on smooth surface. With wheels enabled, HexKitt will move faster when compared to HexKitt in legged mode. When HexKitt is in wheel mode, he will also use less power.

HexKitt follows the design pattern of Kitt in the Knight Rider. He contains the signature design, the LED bar, in the front of the robot. The rate of his flashing will depends on the mood of the pat.

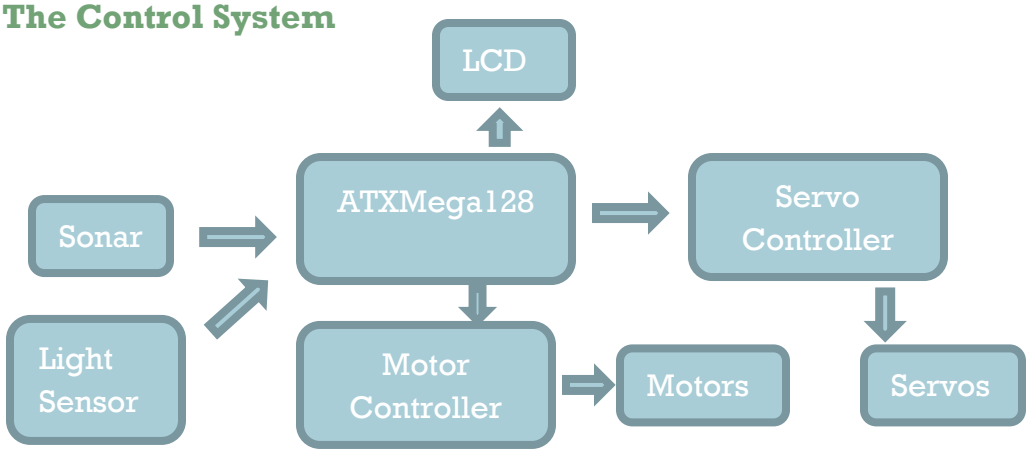
Integrated System

HexKitt uses the Pridgen Vermeer Robotics ATXMega128A1 Microcontroller board for control of all connected components. HexKitt have a collection of sensors, eighteen servos, a thirty-two channel servo controllers, batteries, two motors, driving gears, ball caster, and a graphical LCD for feedback. The design will also contain may LED to enhance the look of the robot.

The Power System



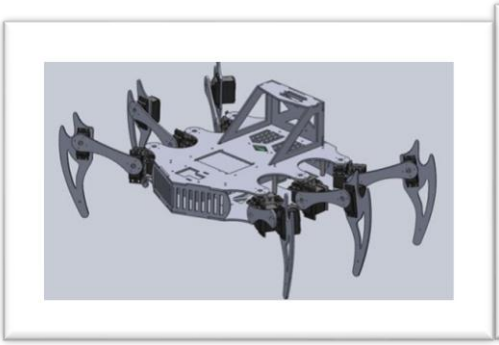
The Control System



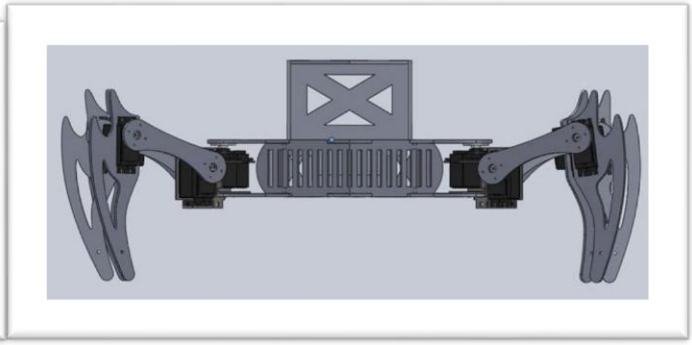
Mobile Platform

Balsa wood is used for HexKitt's platform to reduce price and weight, which also allow many opportunities to customize. The platform will have two main sections: the body and the legs. The body is made of two similar frames sandwiched together with standoffs. The bottom frame will be the host for the wheels platform. HexKitt will have primary processing electronics inside of the body frame. The body frame will have mounting points for all six legs. There will be three legs on each side with a symmetrical design.

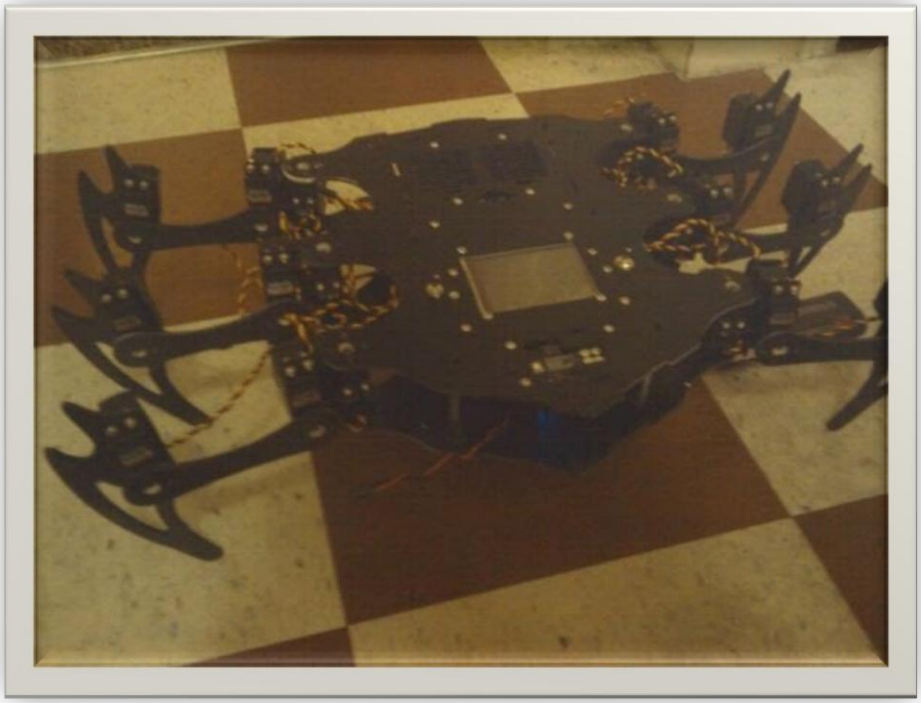
The leg design takes an idea from insects; it has three parts: coxa, femur, and tibia. Each of these parts is connected with servos. Coxa will have a servo attach to the main body provide horizontal movements of the leg. From coxa, there will be second servo attached to provide vertical lift for the femur. There will be a third servo to connect the femur to the tibia, which is the part where it will touch the ground provide movements.



Design Full View



Design Front view

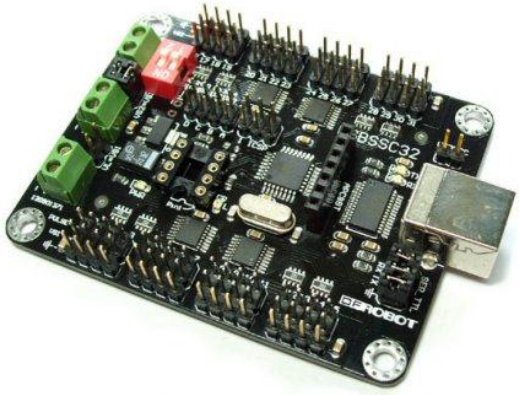


Robot Lift off for the first time.

All Servos are attached as shown. From the front view of the robot, you can tibia on the most right. The horizontal bar is the femur that connects the tibia and the body together. Femur allows the vertical movements of the body. The servo that is attached to the body is the coxa. This join allow the robot to move the leg horizontally. This movement is used to do walk sequence.

Actuation

645MG Servo



USB SSC-32 Servo Controller

HexKitt will use twelve Hitec HS-645MG servos and six Hitec HS-625MG servos for leg motions. Six Hitec HS-625MG servos will provide the horizontal movements of the leg. This particular servo has a speed of 0.15 seconds per 60 degrees and 6.8 kg*cm torque without load when a six volt is supplied. Twelve Hitec HS-645MG servos will provide vertical lift for the robot. This particular servo will provide a torque of 9.6 kg*cm and 0.20 seconds per 60 degrees at no load with six volt supply.

A 645MG and 625MG are combined with a bracket serve as the coxa. The 625MG is connected to the main body frame; the 645MG is connected to the femur part of the leg. The other end of the femur is attached to a third 645MG servo which is also attached to the tibia. Each servo will be controlled by the 32 channel servo controller. The controller will save some processing power from the PVR. It only requires a serial communication between the PVR and controller.

The servos are currently powered by 6 cell NiMH battery. When the robot is walking, the battery power seems not enough to power all the servos. I might have to replace the battery sometimes soon.

Sensors

HexKitt will have two sonar mount in the front to assist in obstacle avoidance. The sonar will accurately detecting objects that's eight inches or further. The HexKitt should start his avoidance movement at around twelve inches in wheels mode, and at around nine inches in legged mode. The ADC in the processor will give about 255 different level of the distance level with 2.0V as reference. In this application, this accuracy should be enough.

LV-MaxSonar-EZ0

OPT101 Monolithic Photodiode

Multiple ambient light sensors will be used to determine if HexKitt is in a dark environment or not. It will allow the HexKitt to act as a pat during the daytime and act like a security portal during the night. Since multiple ambient light sensors are used, they allow you to pat the HexKitt. Basically the light sensor will be spared out on its body; he will lower the part of the body that you cover up with your hand. With multiple points, HexKitt will able to perform a wave move to simulate a patting action. The sensor has the amplifier and other internal component that makes the measure of the ambient light level very easy. This is also sampled with ADC with a 2.0Ref.

Special Senor

This project will not contain a special sensor. The replacement is going to be the mechanically structure that is used to hold the robot up and the walking mechanism.

Behaviors

There will be many behaviors to be implemented into HexKitt. If the HexKitt is in a daylight environment, he will act as lovely pat that surround your life. It will perform a wave pattern as you pat him. He will able go around your house without knocking things around. At night, HexKitt will move on wheels. This behavior enables the robot to save power consumption. When heat is applied to one of the temperature sensor, HexKitt will try to run away from that heat source.

Experimental Layout and Results

The design process of the Hexkitt consists multiple changes. Originally the Hexkitt was designed for walk up to stairs. However the probability of the robot climb up stairs is very small due the mechanical limitation. This includes the limitation of the power consumptions, servo torque, and body frame. The power for a robot of that size to climb up stairs is huge. The servo torque requirement is very high. The servo need pull up the whole body weight. The body frame need be light and strong enough to support all 18 servos. These limitations pushed me to redesign the whole robot structure. Then the design becomes a hexapod that can walk and roll on wheels. The behavior of the robot will be like a pat.

The robot platform was designed with the wheel base. Due to the width of the wheel base physical width, the wooden frame of the body becomes very wide.

This added many complications to the robot's movement design. The weight of the robot is disturbed too far across the horizontal axis. The servos have to take extra torque to keep the body in the air. This was accomplished with purchasing powerful servos.

The most complex part of the robot is the walking sequence. It was decided to use inverse kinematics to be the main movement engine. The study period was very time consuming. After two weeks of development, the robot is moving on its feet with inverse kinematics running. Inverse kinematics enabled a fast and smooth translation between step movements. The robot can move its legs with a fair accurate movement.

Conclusion

Before take IMDL, I had little experience with working robotics. I have some experience in embedded processors programming. This helped me a lot to do c code programming in AtXmega128. I had never design any mechanical system that Hexkitt have. The process was very challenging.

The biggest problem was time. There is so many problems need to be solved for the HexKitt and how little time I had to complete. Solidworks was also another big problem for me. This is was the first time for me to design some kind mechanical system in that software.

In the process of development, I learned how to calculate inverse kinematics of a 3 degree of freedom joints. I also learned a brand new language that was developed for my graphical LCD.

Documentation

- PVR Board
- ATxMega - http://www.atmel.com/dyn/resources/prod_documents/doc8067.pdf
- SSC-32 Controller - http://www.lynxmotion.com/images/html/build136.htm
- MaxSonar-Ez0 - http://www.pololu.com/file/0J68/LV-MaxSonar-EZ0-Datasheet.pdf
- TMP 37 - http://www.analog.com/static/imported-files/data_sheets/TMP35_36_37.pdf
- OPT101 - http://focus.ti.com/lit/ds/symlink/opt101.pdf
- 4D LCD - http://www.sparkfun.com/products/10089
- Motor Driver - http://www.pololu.com/file/0J65/sn754410.pdf
- Phoenix Code - http://www.lynxmotion.com/images/html/proj098.htm
- Bluetooth - http://www.dfrobot.com/wiki/index.php?title=DF-BluetoothV3_Bluetooth_module_(SKU:TEL0026)

Appendices

The code can be found at following site

https://sites.google.com/site/digikitt/