Ninja TurtlEEs

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PROBLEM—Water loss in Bowman Creek

Bowman Creek, a tributary of the St. Joseph River has been losing its ability to sustain life for years, lowering property values along the watershed and not supporting the local ecosystem as it could. The water level of the creek decreases as it travels toward the St. Joe River, so South Bend engineers believe the water has been draining into sewer tunnels running underneath the creek. The city needs a new robot to search the pipes for potential leak points.

SOLUTION—Wireless Sewer-Dwelling Robot

South Bend's current robot cannot clearly view the high ceilings of the six foot diameter pipes, so any cracks at these points cannot be clearly viewed without the city sending a human in its place. Also, the current robot has trouble with debris in the pipe pathways. The Ninja TurtlEEs designed and prototyped all aspects of a new robot that confronts both of these problems, allowing operators to safely navigate the pipe and clearly search for cracks.

ENGINEERING

Controllable camera and LED

Two servomotors allow the camera to be pointed in any direction, including directly up and toward the floor directly in front of the robot. One servo turns the baseplate, and the other moves the camera itself. A high powered LED bulb sits below the camera to help in the dark sewer environment.

Infrared obstacle detector

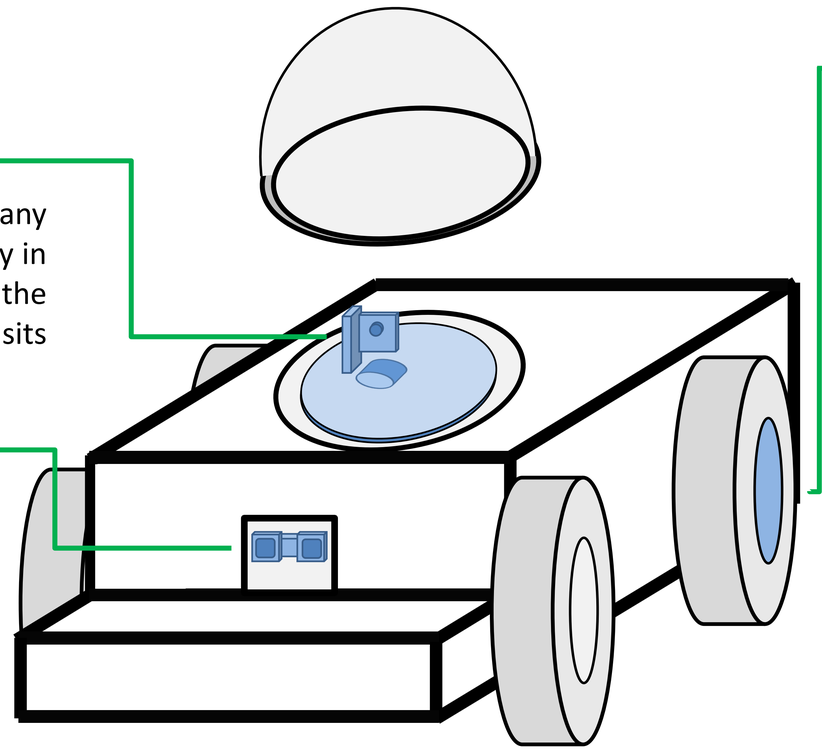
An infrared sensor angled slightly toward the ground allows the robot to notice obstacles which disrupt what should be a constant distance measurement.

Raspberry Pi

A Raspberry Pi acts as the personal computer of the robot. An Xbox controller sends commands through a router to an antenna on the Pi. The Pi sends the commands via SPI to the microcontroller while receiving sensor data and transmitting it back to the user. All data is visible on a curses-based GUI.

Body design

The box design allows for a large amount of interior space for the 12V battery and all of our electrical systems. The large diameter of the wheels and the front wheels' extension in front of the robot allows for it to cross smaller obstacles and also be lowered front first into a man hole.



Accelerometer

By periodically checking the horizontal forces on the accelerometer, the robot can determine its tilt and warn the user if it rotates too far in any one direction. Also, if the robot is in the "danger zone" for too long, it will auto correct to keep the robot from falling. This feature is necessary because of the sewer's curved walls.

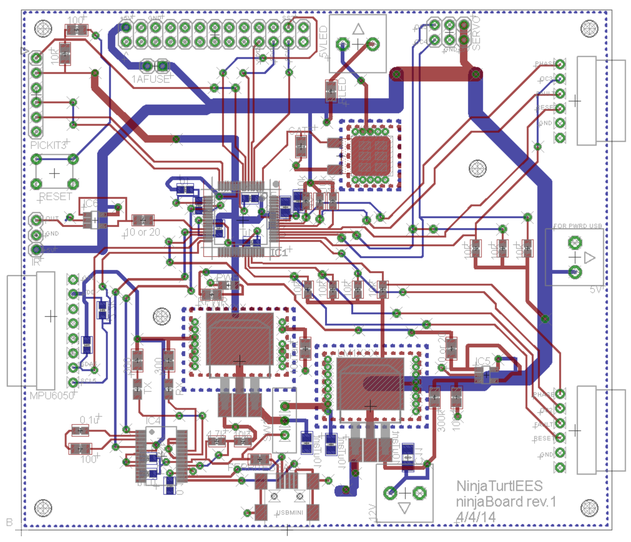
Rear-wheel drive

Two H-bridge drivers independently control the motors by pulse width modulation to MOSFET gates. By turning the motors at different speeds, the robot can turn.

Control board

The team designed the PIC32-based control board so that it can do the following:

- Raspberry Pi communication (SPI)
- Analog inputs with unity gain op-amps for testing battery level and checking infrared sensor.
- Accelerometer and gyroscope interface (I^2C)
- Pulse width modulation for controlling servomotors and H-bridge drivers
- UART support via USB
- Microcontroller programmability and reset
- External Powered USB support
- 12V, 5V and 3.3V power rails
- MOSFET driven external LED



Battery management

An on-board battery level A/D converter allows us to check the current battery level and warn the user if the battery level gets too low. The robot is designed to last for three hours per 15Ahr battery.

FUTURE WORK

- Add an auto-scan mode which takes pictures and stiches them together in a "Google Street View"-type interface.
- Implement an auto-return mode by detecting movement with the accelerometer and saving and repeating the path taken.
- Select and purchase a strong enough router to communicate far down a sewer pipe.
- Design a new body for better water protection and simpler access to the battery and on switch.

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