

ECE4011/ECE 4012 Project Summary

Project Title	Bridge Inspection Robot
Team Members (names and majors)	Sean Csukas, EE
	Kristen Fernandez, CmpE
	Erikzzon Latoja, CmpE
	Justin Tamayo, CmpE
	Sanmeshkumar Udhayakumar, EE
Advisor / Section	Dr. Patricio A. Vela
Semester	Year/Semester Spring 2017 (ECE4012)
Project Abstract (250-300 words)	<p>The purpose of the Bridge Inspection Robot is to navigate metal bridges and record structural vibration data, which can then be used to monitor the structural health of these bridges over time. Prior to the conception of having such robots as mobile sensors, a series of accelerometers would have to be placed along a bridge by hand, and then re-positioned for each new set of recordings. Utilizing Bridge Inspection Robots will dramatically speed up vibration data collection, allowing for faster structural analysis and identification of faults and issues.</p> <p>The Bridge Inspection Robot, upon initialization, wirelessly connects to a computer and receives commands from a human inspector. The robot is instructed to traverse the frame of a bridge. The robot can move without falling off the bridge via pathfinding, utilizing onboard IR sensors that detect the bridge's edges. As the robot traverses the bridge, it takes measurements of the bridge's frequency response with an attached accelerometer. This data is then wirelessly transmitted back to the computer for storage and later processing.</p> <p>A previous iteration of the Bridge Inspection Robot exists; this version uses magnetized wheels to secure the robot on a metal bridge. This design has been proven to function as intended, though it lacks the ability to turn left or right. Given that this design is also five years old, the project team intends to eliminate obsolescence by implementing mechanical and electronic improvements with a ground-up redesign. One considerable upgrade was the change to a three-wheeled design which provides increased maneuverability. The robot has two large, motorized, magnetic front wheels and a rear, unpowered omni-wheel that is also flanked by magnets. A prototype robot designed with consumer off-the-shelf parts costs approximately \$450.63.</p>

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List codes and standards that significantly affect your project. Briefly describe how they influenced your design.	<ul style="list-style-type: none"> - SPI (Serial Peripheral Interface Bus): This is a synchronous bus interface protocol that is widely used for its simplicity in both setup and operational overhead. It is used to transfer data between the robot's microcontroller and the wireless RF module, as well as the accelerometers. - USB (Universal Serial Bus): This is a bus communication protocol. It will be needed to interface a microcontroller to a computer for debugging purposes with an IDE. - IEEE 802.15.4: This is a protocol defined by IEEE for low-rate, wireless, personal area networks. It is a point-to-multipoint protocol that, unlike mesh protocols, ensures that all other nodes in the network receive commands from a sending node at the same time, provided that they are all within range of the sending node. - C: C is a programming language. It is used to program the microcontroller, which controls the robot's functions.
List at least two significant realistic design constraints that applied to your project. Briefly describe how they affected your design.	<ul style="list-style-type: none"> • Cost – The Bridge Inspection Robot needed to be designed with cost in mind, so consumer off-the-shelf parts were used. • Accel range – The expected measurement range of 0-50 Hz led to the choice of the ADXL355 Digital triaxial accelerometer due to the need of a precise measurement on the inspected bridge. • Weight – Given the ideal that the Bridge Inspection Robot could be delivered to its area of operation by way of quadcopter, the Bridge Inspection Robot was set to be at most 1 kg. • Power Capacity – The expected time of operation of one hour led to the decision of the 3S Lipo Battery.
Briefly explain two significant trade-offs considered in your design, including options considered and the solution chosen.	<ul style="list-style-type: none"> • Computing platform: microcontroller vs microprocessor - While a microprocessor would provide faster computing performance, the higher power requirement of a microprocessor would reduce the battery life of the robot. A microcontroller was more appropriate because it was simpler to program and consumed less power, and the decreased speed should not have significantly affect performance. • Wireless Protocol: 802.15.4 vs. Bluetooth – For connecting the robot to a server, Bluetooth would have been a simple means of wireless communication, and the Bluetooth Low Energy (BLE) protocol would have required little power consumption. However, the short range of Bluetooth (~100 m) is a significant limitation. 802.15.4 provided a range of up to 1.2 km, which was better suited for this application.
Briefly describe the computing aspects of your projects, specifically identifying hardware-software tradeoffs, interfaces, and/or interactions. <i>Complete if applicable; required if team includes CmpE majors.</i>	<p>Because our project is a robot, there are numerous hardware-software aspects within the design:</p> <ul style="list-style-type: none"> • CPU – A microcontroller will served as the computing core of the robot. The microcontroller is responsible for receiving input from sensors, sending data to the wireless transceiver, and controlling the robot's servos. • Sensors – The robot has an accelerometer for sensing bridge vibrations, as well as several IR sensors to detect edges and prevent the robot from falling. These sensors communicate with the CPU via SPI. • Wireless transceiver - A wireless communications module sends/receives data between the robot and an external server. A more powerful transceiver provides better range and fewer transmission errors, but would have substantially increased the robot's power consumption. • Batteries – The robot needed to have a sufficient battery life to be

	<p>effective. If the robot's battery died during bridge inspection, the robot would be left stranded atop the bridge. The selected battery for our design had a high enough capacity for operation while also minimizing cost.</p> <ul style="list-style-type: none">• External server - A PC sends commands to all the robots in the sensing network, such as beginning or stopping inspection. The server collects all the data sent from the robots and store it for future analysis.
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