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A Reconfigurable Multipurpose SoC Mobile Platform for metal detection

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Background and Objectives One of the key problems in mobile robotics is the ability to understand and analyze the surrounding environment in a useful way. This is especially important in dangerous applications where human involvement should be avoided. A clear example of employing the robots in dangerous applications is mine detection which is mostly done through metal detection techniques. Among the various types of walking robots, Hexapod walking robots offer a good static stability margin and faster movement especially in rough terrain applications [1] Thus, the "Hexapod Terasic Spider Robot" is a suitable platform for the metal detection purpose especially that it is equipped with Altera DE0-Nano field programmable gate arrays (FPGA) SoC which allows for extremely high performance and accuracy. This work introduces a novel implementation of a metal detection module on the Terasic Spider Robot; the metal detection module is designed and interfaced with the robot in order to perform the metal detection. The user can control the robot and receive the feedback through a Bluetooth-enabled android phone. In addition, a general-purpose design flow that can be used to implement other applications on this platform is proposed. This proves the versatility of the platform as well.Method The designed metal detection module (MDM) is mainly based on an oscillator and a coil, its operation principle is that when the coil approaches a metal, the frequency of the oscillator will change [2]. This frequency change can be accurately monitored in real time using the FPGA SoC board. Thus, the module can be used for detecting metals. The metal detection module is interfaced with DE0-Nano SoC board where the detection algorithm

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is implemented. The development of the algorithm is carried out on the board available on this robot. The board includes a FPGA, which provides a high-performance and real-time implementation of parts of the algorithm, and a hard processor system (HPS) running Linux OS which can be used to easily interface the board with other computer systems and peripherals such as mobile phones and cameras[3]. As shown in figure 1, the detection algorithm is based on hardware/software co-design; the output of the MDM is provided to the FPGA part of the board in order to achieve an accurate and real-time monitoring. Upon detection, the FPGA sends a detection signal through the shared memory interface to the HPS part of the board. The HPS is then responsible for sending a warning to the mobile through multi-threaded communication application that is running on the HPS. Figure 1 General architecture of the metal detection system In order to implement the metal detection algorithm on the Terasic Spider Robot, it was necessary to formulate and follow the design flow provided in Figure 2. This design flow can be used to implement other applications that can utilize the hardware/software co-design approach for better performance. Figure 2 General purpose design flow for the Altera Terasic Spider Robot Platform. Results and discussion Due to the coil specification and the circuit design. The frequency captured at normal situations is (no metal presence) is 2155 ± 20 Hz. The frequency increases Inversely proportional to the distance of the metal from the coil. In other words, the frequency increases when the distance between the metal and the coil decrease. When a metal whose size is at least the same size as the coil is present at 7 cm distance from the detection coil, the frequency will exceed 2200 Hz Regardless of the medium. The tested medium is wood. However, similar results were obtained with air medium. These numbers are specific to the proposed system. Changing the circuit parameters will increase the detection distance if desired. For example, having more coil turns and bigger diameter as well as faster oscillation will increase the detection distance. To avoid any interference between the robot body and the metal detection circuit readings, a 15 inches plastic arm is used to connect the metal detection module to the body of the robot. The electronics components is attached to this arm to the nearest possible point to the coil. The metal detection module attached to a plastic arm and then to the robot. the metal detection module and the spider robot is shown in Figure 3 and 4 respectively. Figure 3 The Metal Detection Circuit Combined with the Arm Figure 4 MDM Connected to the Terasic Spider Robot The robot is then controlled through a mobile application, the mobile application is modified so that the robot can send feedback (detection warning) to the mobile phone. Figure 5 shows an example of the notification message «Metal Detected» whenever a metal is detected. Figure. 5. Metal Detection Message for Mobile Application Interface Summary and Conclusion This abstract includes a general description of research project that aims to utilize the Terasic Spider Robot platform to perform accurate and real-time metal detection. This is an important application that helps humans avoid involvement in dangerous operations like mine detection. Nonetheless, a general-purpose design flow is proposed for the benefit of the research community and anyone who intends to implement an application on this platform in the future. Acknowledgment This project was funded by Qatar University Internal Grants program. References [1] Y. Zhu, B. Jin, Y. Wu, T. Guo and X. Zhao, «Trajectory Correction and Locomotion Analysis of a Hexapod Walking Robot with Semi-Round Rigid Feet», Sensors, vol. 16, no. 9, p. 1392, 2016. [2] T. Alauddin, M. T. Islam and H. U. Zaman, «Efficient design of a metal detector equipped remote-controlled robotic vehicle,» 2016 International Conference on Microelectronics, Computing and Communications (MicroCom), Durgapur, 2016, pp. 1-5 [3] «Cyclone V Device Overview», Altera, 2016. [Online]. Available: https://www.altera.com/en_US/pdfs/literature/hb/cyclone-v/cv_51001.pdf. [Accessed: 16- Oct- 2017]