Detecting Cracks in Concrete Structures Using a Deep Learning Wall-Climbing Robot

Saturnino, Anthony (School: Bishop Ryan Catholic Secondary School)

Current concrete structure inspection methods can cost on average $7500US per day. Cracks in concrete caused by forces can lead to long-term instability and serious structural problems. Nowadays, with the abundance for bridges in our world, it is important to have a detailed inspection of concrete bridges and structures to maintain proper safety. The purpose of my project was to design and build a cost-effective apparatus of detecting cracks in concrete structures. Using the iterative design process, I engineered a concrete wall-climbing robot. The robot consists of a body and 2 arms that utilize foam suction cups powered by a pneumatic system, combined with 4 Nema 17 high torque stepper motors controlled by a 3D printer board (FYSETC Spider V2.2). After 30 iterations, the final prototype can climb 10 feet per hour and using a built-in imaging system, capture 1 photo every 30cm. The data collected by the robot is transferred to a workstation that runs a CNN (Convolutional Neural Network) that was programmed in python and trained using 20,000 images of cracked concrete and 20,000 images of non-cracked concrete. The CNN was able to detect cracks with an accuracy of 99.5%. The location of the crack is determined by the XY coordinates of the robot. This is determined using an edge detection algorithm I created, comprised of lidars and servo motors. The system has the advantage of taking photos up close to allow the CNN to more accurately predict whether a crack exists or not. Furthermore, the system can run completely autonomously. I was able to complete a working prototype with a cost of less than $3,000US and a commercial version production cost of less than $5,000US.

Awards Won:
Second Award of $2,000
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: Full Scholarship from King Fahd University of Petroleum and Minerals(KFUPM) (and a $400 cash prize)
King Abdulaziz &amp
his Companions Foundation for Giftedness and Creativity: NOT TO BE READ -- $400 cash prize for each Full Scholarship from King Fahd University award recipient
International Council on Systems Engineering - INCOSE: Second Place INCOSE Best Use of System Engineering Award of $800, a 1-year free student membership to INCOSE, and free virtual admission to the 2022 International Symposium of the INCOSE
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