Autonomous Battery Swapping Project

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Background

Nowadays, many mobile robots run on batteries, including drones and rovers. However, the batteries run out eventually. At this point, either the batteries need swapping or the robots need charging.

The potential issue with tradition swapping of the batteries is that most of the connectors are quite complex. Either human involvement is needed or considerable amount of work has to be put into research. For the former, the whole system can't run autonomously; for the latter, the system is hard to scale due to lack of flexibility. On top of that, the robots would reboot during swapping.

Charging robots has already been achieved by the mature Kiva System of Amazon Robotics. The Kiva system is a rover that autonomously carries packages from the shelves. It follows line on the floor to mate with charger plugs and get charged. It is relatively easy for rover to mate with plugs but hard for other robots, especially drones. Another disadvantage is that the charging requires robot to resting so it results in a lower average run-time for each robot and lower efficiency.

A similar alternative to charging robots is to have the robot cabled at the cost of messy cables that might get in the way.

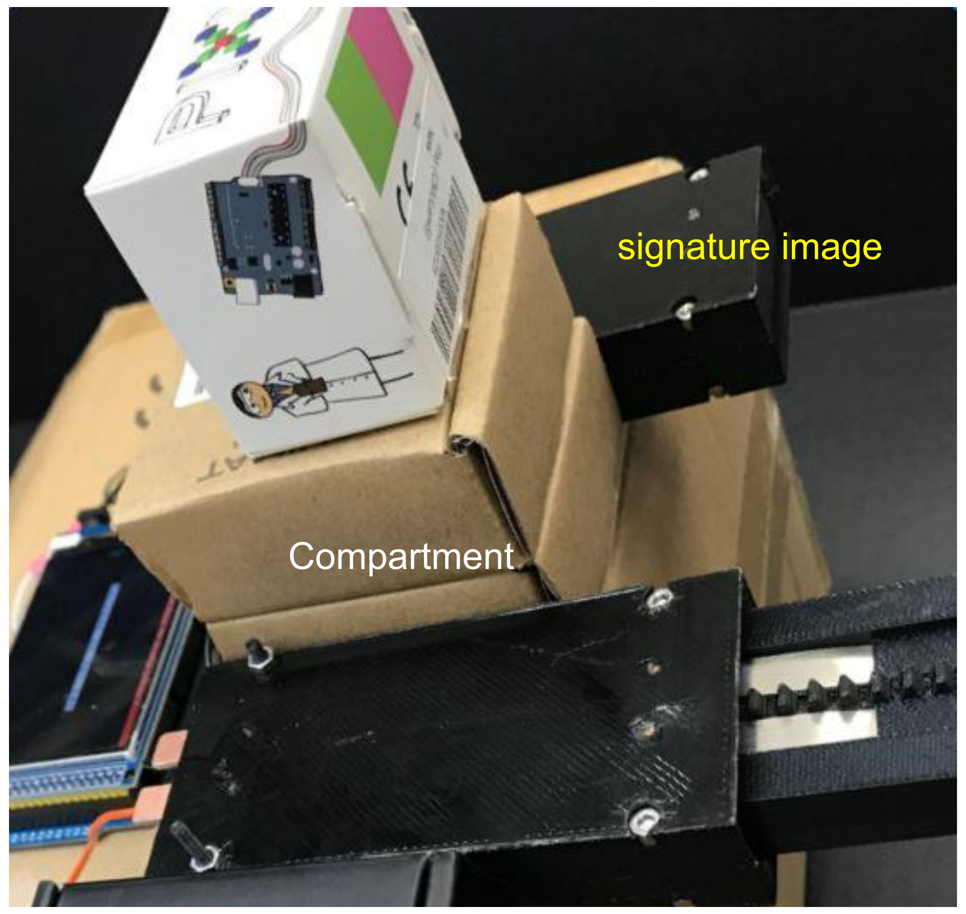
Proposed solution

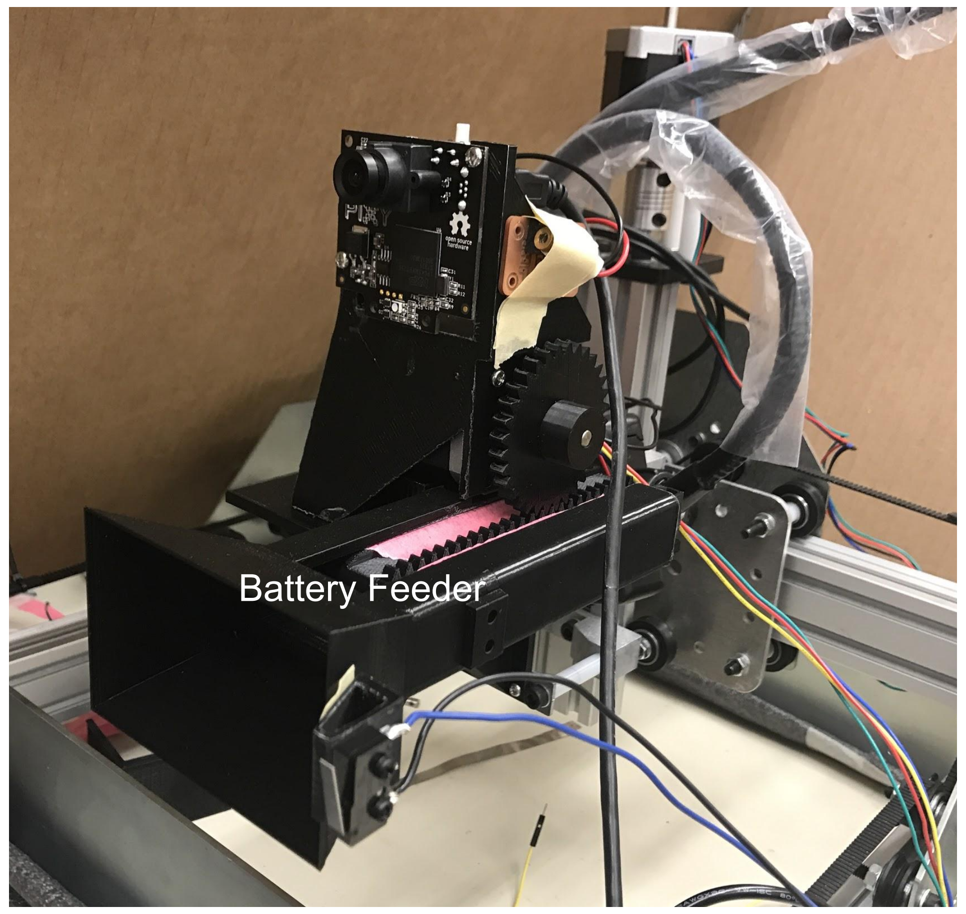
A battery swapping system is proposed to automatically swap the batteries in electrical appliance/robots. The system contains three parts: enclosures to wrap the battery into an easy-to-swap shape, compartments to house enclosure and provide power and battery feeder to feed the enclosure into compartment.

The compartment and enclosure are designed so that when enclosure is inserted into the compartment, the old enclosure is also pushed out from compartment. The swapping process is designed to be a single one-directional linear movement. The connection remains during swapping.

The Battery Feeder needs to be automatically aligned to the Compartment on a mobile electrical appliance, which can be achieved by employing computer vision, laser or sonar. No human labor is needed while system runs.

Current Design

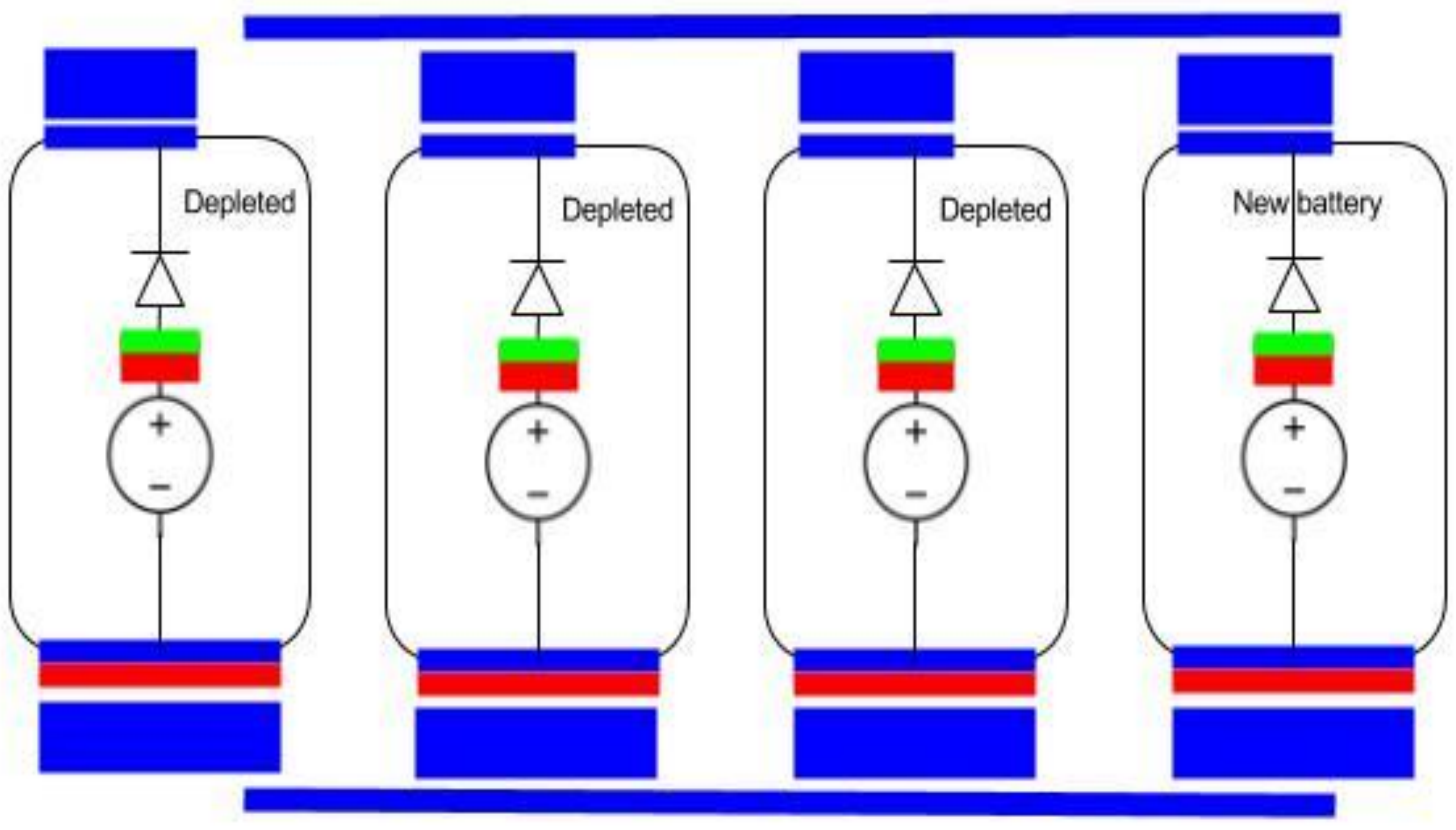




Lithium-polymer battery cells are enclosed in 3D-printed enclosures (middle) with two exposed nickel strips as electric contact. The length of the strips allows a greater effective contact areas. Compartments (left) are housings for batteries and enclosures and provide corresponding serial or parallel connection. It has leafy spring inside to ensure good contact with the nickel strips on the enclosure.

In our prototype design, the movement is enabled by a CNC machine frame. For a swapping process, the mounted pixy-cam is used to find the signature image and guide the alignment of the battery feeder with the compartment. New batteries are inserted by the feeder, while driving out the old batteries during insertion.

Mechanism Illustration & Result



Different voltages and battery capacities could be achieved by wiring the terminals of the compartments and make different combinations. Thus it is very flexible.

The swapping mechanism could be illustrated with the diagram on the left. The blue rail on the top and bottom indicates the positive and negative connection on the compartment. In this example, we have 3 batteries connected in parallel. The new charged battery is inserted from right while pushing a depleted battery out. The fewer batteries the rail has, the easier it is for connection to break and result in unstable voltage.

It has been tested that even if only one battery is in the grid, the output voltage is stable enough not to reboot an arduino.