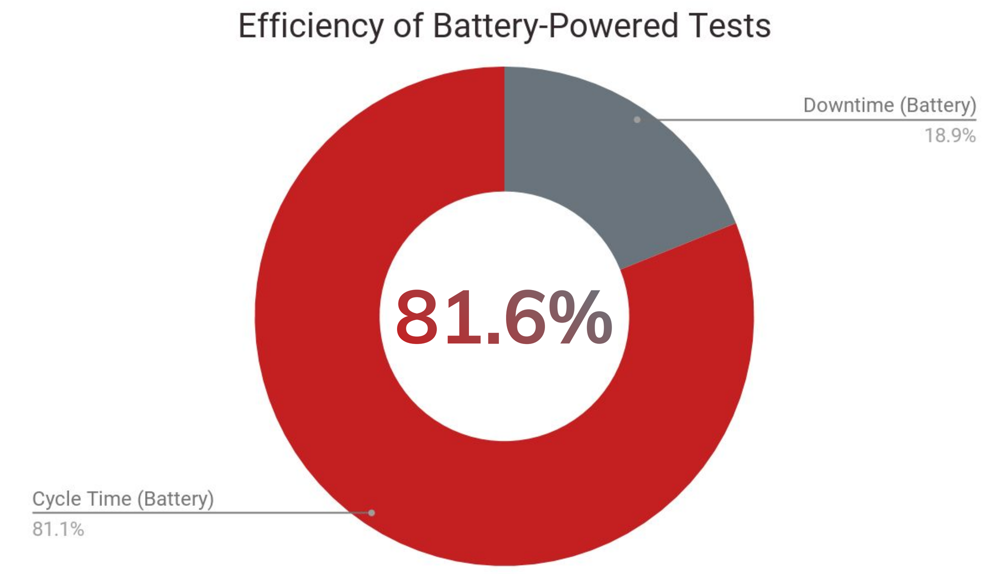
AUTOMATED INDUCTION ROBOTICS

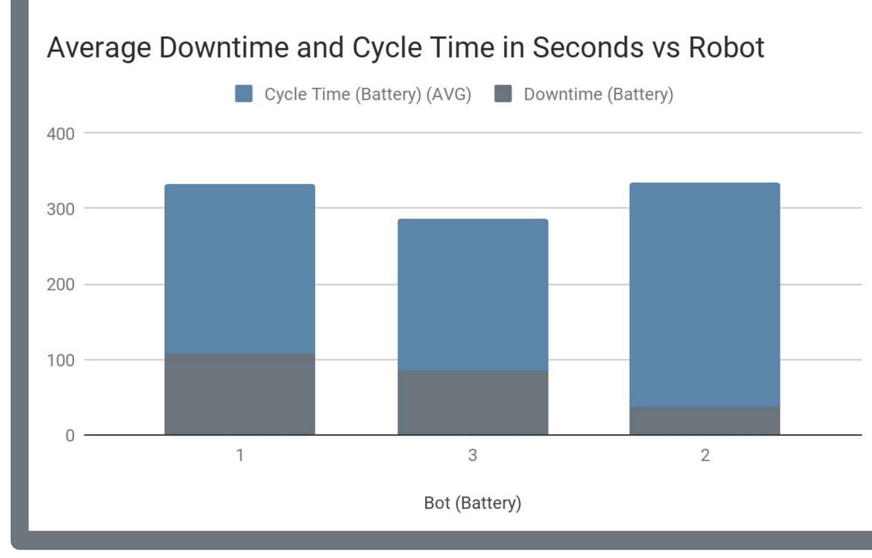
Introduction

Automation is a global market, expected to grow near to $250 billion by 2021 (*Statista*, 2019). Since their purchase of the robotics startup Kiva in 2012, Amazon has become a giant in this field (*Kessler*, 2019). Their army of 100,000 robots make them faster and more efficient than their competition (*Amazon Day One*, 2019). Automated inventory robots came in many different forms but with one distinctive flaw, batteries. These robots are not cheap and their gigantic, near-$1000 batteries have to charge for an estimated 4 hours every day (*Aegis Battery* and *Mobile Industrial Robots*). That is a lot of overhead simply plugged into an extension cord. However, imagine automated robots, moving freely around a warehouse 24/7, free from the weight, and cost, of a battery pack powered through a grid of wirelessly inductive "Smart Tiles" in the floor, each loaded with sensors to help coordinate robot movement, avoid obstacles, and report on warehouse conditions.

Net Weight Transported by Induction

101,858 Kilograms





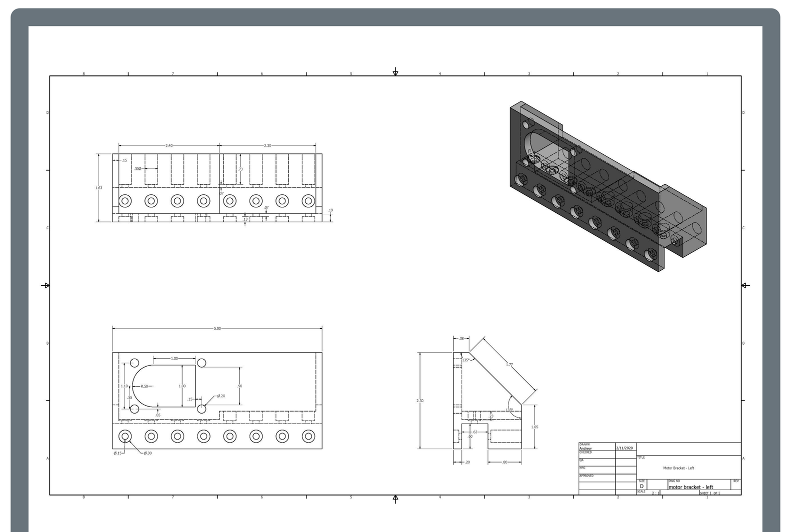
OEE of Induction Robots is 30.7% Higher Than Battery-Powered Alternatives

Conclusions

When reviewing the data, it is clear that an Induction system has numerous benefits over a typical battery-powered system. Robots powered by induction boasted better OEE, Efficiency, and Cycle Times comparatively. This confirms the hypothesis that an induction system would win out when it comes to KPIs. However, there are a few drawbacks to this system that was discovered in testing: induction requires extensive infrastructure and high amperage draw of multiple robots would require regulated 'grids' to avoid failure. When it comes to ROI, induction could be well suited for large-scale warehouses due to its potentially lower maintenance costs and robot overhead.

Research Question

The aim of this experiment is to determine if Automated Induction Robotics are safer, smarter, and more efficient than standard, battery-powered systems. I will determine this by using long-term ROI, measuring power consumption, and key robotics metrics such as: Overall Equipment Effectiveness (OEE), Cycle Time, Cycles Completed, Utilization, Efficiency, and Wait Time.



Average Cycle Time (Battery) vs. Average Cycle Time (Induction) in Seconds

262.6

↑117.74%

Job Creation — The Java "Taskmaster" algorithm plans out routes for robots to take across the grid to complete their jobs.

Database Storage — The Taskmaster algorithm outputs it's navigation data into an AWS Dynamo DB table.

Raspberry Pi — The Raspberry Pi locally runs a Python algorithm to retrieve data from the table and send it to the robot in JSON.

Induction Robot — The robot receives the data via MQTT, then parses it into instructions for the motors and actuator.

Data Collection — As the robot executes it's jobs, it records data on it's performance and sends it to AWS IoT Analytics.

Procedure

To test the effectiveness of Automated Induction Robotics, mock warehouse environment similar to Amazon's Fulfillment Centers was created. It consisted of a 5 by 5 grid of Smart tiles (2 sq ft each) and 2 shelves of the same size placed on certain tiles. The shelves will be weighted with varying amounts (200 and 300 lbs) to simulate payloads. The robots were randomly assigned "jobs" to travel to a shelf, pick it up, deliver it to a picking or packing station (in each of the 4 corners of the grid), then place the shelf on the next available tile. They navigated via a Java pathfinding algorithm that coordinated movement to avoid collisions. Data was recorded in the cloud to determine when each tile should turn on or off and to keep track of KPIs. This system was tested against a control group of battery-powered robots.

Materials

- High - torque 30 rpm worm gear motor (2)
- Arduino MKR WiFi 1010
- Castor wheels (2)
- 10" drive wheels (2)
- Adafruit BNO055
- 1500N linear actuator
- Motor encoder (2)
- Motor driver (2)
- Raspberry Pi
- 10A power supply
- Signal generator
- Raw materials for the construction of the tiles and robots
- Miscellaneous electronic components

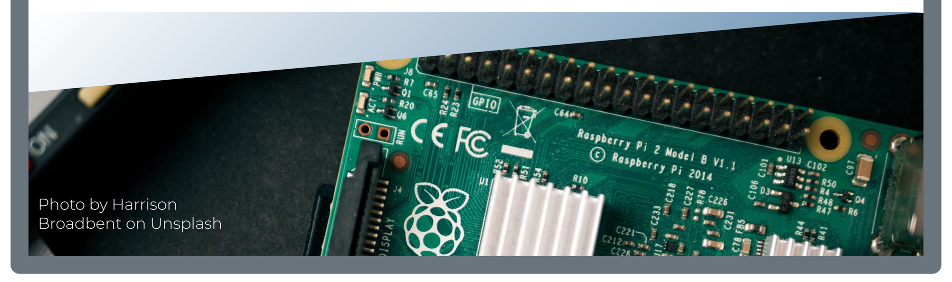


Photo by Harrison Broadbent on Unsplash

Results

Due to delays and multiple issues regarding the robot's drive system, full-scale, real-world tests were not achievable by the project's deadline. As an alternative, the fully operational Java algorithm that coordinates the robots' movement, which was accurate in predicting the robot's real-world movement within a fraction of a second, was retooled to output theoretical data of real world tests. It ran 1000 simulated 'jobs' for 3 robots running on a 5 x 5 grid carrying shelves weighing 68, 91, 113, and 137 kilograms. Battery tests had each robot stop to recharge for 30 minutes every 3 hours. This value was determined by the runtime of Amazon's Hercules robots, 20 hours of runtime with a 4 hour charging period. Overall Equipment Effectiveness (OEE) is a metric used for measuring productivity in working robots. It was calculated using the formula: (actual run time / planned run time) x ((average cycle time x total cycles completed) / run time). Efficiency was determined by 100% - the sum of all the robots' downtimes divided by the total run time. Net weight is determined by the sum of the weights of all the shelves the robots picked up and moved in the simulation.

Works Cited

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