Autonomous Roof Shingler

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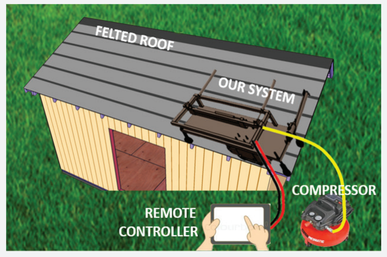
Problem Statement

Roofing work is strenuous and tiring. It involves climbing and bending and a lot of repetitive manual work. Work-related injuries for roofers are among the highest of all occupations.

An automated robotic system can make shingling a roof safer, more efficient and cost-effective.

Use Case

1. User interacts with the robot through the controller
2. User first loads the robot with shingles
3. User then presses the "Start" button.
4. The Robot lays shingles on the roof row by row, it also cuts shingles to size at the edges of the roof.
5. The robot returns to the initial position and alets the user if it needs to be restacked.
6. The Robot informs the user once the roof is shingled.

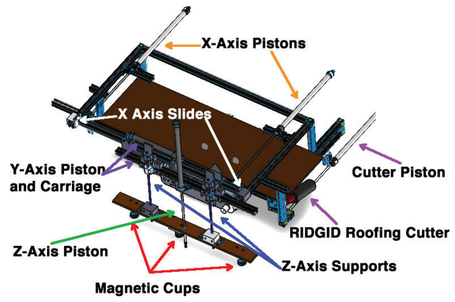


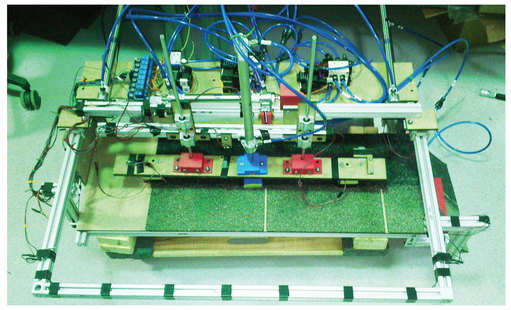
Requirements

1.1 Robust Construction
1.2 Operate on Roofs with Different Pitch
1.3 Industry Standard of Shingling
1.4 Stable Operation on Roof
2.1 Lay shingles accurately on roof
2.2 Size Shingles at Roof Edges
2.3 Shingles in timely manner
2.4 Return to be refilled
2.5 Notify the user shingling is “finished”

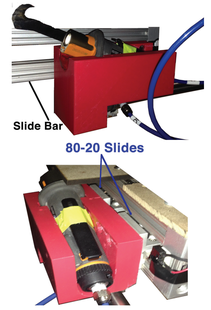
Subsystem Details

Laying System

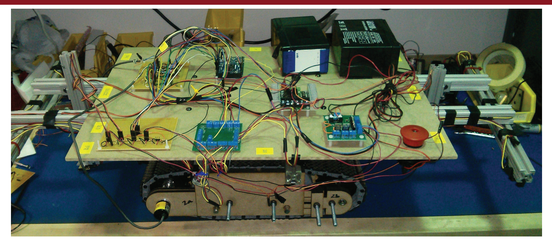


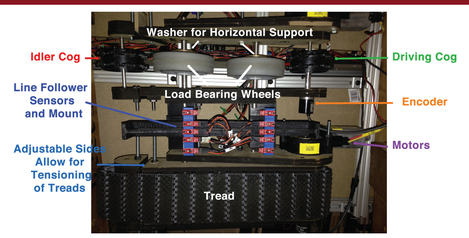


Cutter



Locomotion system

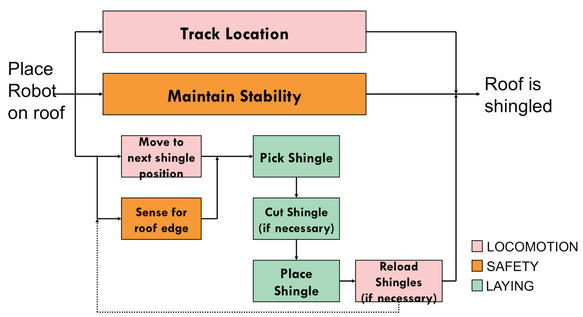




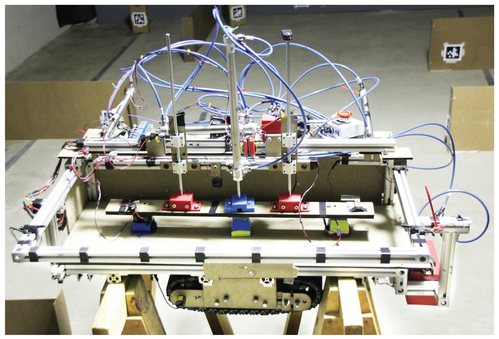
Off Board Controller

The controller has the following functions:
1. Start the robot
2. Stop the robot
3. Indicate if shingles are empty
4. Command robot to continue shingling.

Functional Architechture



Final System

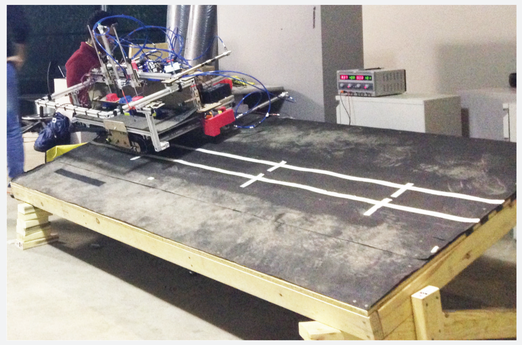


Challenges

1. Mechanical failure of locomotion treads due to tension issues during operation on slanted test-bed.
2. Weight imbalance of the integrated system and hence diffi culty in moving in a precisely straight line.
3. Shingle pick-up mechanism design changes from suction cups to sealing clay to magnetic attachment.

Testing - Success Conditions

- ⓧ Spacing between shingles is between 0.75” and 1.75”.
- ✓ Maximum alignment difference between consecutive shingles is <= 1”.
- ✓ Distance between top edges of successive shingle rows is between 5.75” and 6.25”.
- ✓ Length of the shingle piece cut off measured along the longer side of the shingle is between 5.75” and 6.25”.
- ✓ The entire operation of laying two rows of shingles is completed in 20 min



Lessons Learned

1. Avoid designing over-complicated mechanisms. Use readily available tread designs.
2. Scaling up design from initial mock-up is time-consuming and unforeseen integration issues will occur.
3. 3D printing is good but parts will have low load-bearing capabilities.

Acknowledgements

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