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CS502157

Spot on Site: Maximizing Jobsite Robotics for Evaluating Housekeeping

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Learning Objectives

- Understand the project origin and collaborative innovation approach to this project.
- Learn about the iterative solution to automating housekeeping inspections.
- Learn how to implement a robust testing procedure for evaluating the value-add of Spot compared to a human.
- Identify strengths and challenges in Spot's ability to navigate a construction jobsite and repeat missions over time.

Description

During this session, we will highlight the research collaboration formed between Skanska USA and Autodesk to identify and develop construction use cases for Spot, the mobile robot by Boston Dynamics. After conducting testing at the Autodesk Technology Center and Skanska jobsites in Boston, we evaluated Spot's ability to execute repeatable, autonomous missions that document and analyze jobsite housekeeping, while benchmarking Spot versus human operators.

Speaker

Brooke Gemmell is an Emerging Technology Manager at Skanska and one of ENR's Top Young Professionals of 2022. Brooke has distinguished herself at Skanska as an innovation powerhouse. Brooke developed her skillsets at the Jacobs Institute for Design Innovation while studying Civil Engineering at the University of California, Berkeley. At Skanska, Brooke is responsible for driving innovation and new technology adoption on all projects in Oregon. Brooke also facilitates national technology pilot programs and enterprise rollouts, providing her insights to key innovative strategy development. Brooke is deeply knowledgeable in the full range of construction technology solutions and is constantly searching for the highest impact tools. She was named a 2020 Innovator of the Year Finalist in the Autodesk Excellence Awards.

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Collaborative Approach to Innovation

Back in August of 2021, Autodesk launched a call for proposals looking for novel use cases for Boston Dynamics' Spot robot. Rather than jump into a specific use case, Skanska held an ideation session at Autodesk's Boston Technology Center with local Skanska team members. After a day of brainstorming and evaluating feasibility, the team determined that automating housekeeping inspections provided the most robust opportunities for discovery and impact to Skanska projects.

The collaborative approach to this project allowed all parties to leverage the unique strengths of each company. Working together, Skanska, Autodesk and Boston Dynamics tackled this project with a breadth of resources and perspectives.

Boston Dynamics

Provided Spot hardware and expertise for maximizing use of Spot.

Autodesk

Provided Technology Center lab space, technical support and access to the Autodesk Outsight Network.

Skanska

Provided construction experience and led jobsite testing in Boston at active Skanska construction sites.

Iterative Solution to Automating Housekeeping Inspections

Due to the limited duration of the project, Skanska's team focused on mapping out an iterative solution to automating housekeeping inspections. As the technical solution developed, the team could experiment with varying levels of automation.

The below workflow outlines the iterations of the technical solution:

- At the end of the day, Spot runs an autowalk, informed by the Housekeeping Scorecard, capturing photos around the project.
- Photos are uploaded to the cloud and analyzed with an iterative approach as our technical solution develops:
  - **Human Analysis:** Photos are analyzed by a human operator to fill scorecard and human takes remedial actions.
  - **Human/ML Analysis:** Photos are analyzed by ML model and human operator to fill scorecard and human takes remedial actions.
  - **ML Analysis:** Photos are analyzed by ML model to fill scorecard and human takes remedial actions.
  - **Real-time Analysis:** Site conditions are analyzed by ML model in real time by onboard Spot computer. Spot identifies housekeeping discrepancies and human takes remedial actions.
  - **Real-time Remediation:** Site conditions are analyzed by ML model in real time by onboard Spot computer and Spot takes remedial action to address the issue.

Robust Testing Strategy

Before the team began testing, we discussed what were the key factors at play. We had the unique opportunity to test in a controlled lab environment, as well as a real-life construction jobsite. We chose to evaluate Spot's maneuverability and agility in both of these environments. Additionally, we wanted to compare the impact of Spot vs. a human operator for both capturing content and navigating a jobsite.

At the Technology Center, we focused on understanding how to operate Spot. We learned how Spot responded to different obstacles, and how to plan, record, and run autowalk missions. Additionally, we tested several mounts for capturing 360 photos and learned how these impacted Spot's obstacle avoidance and ability to navigate below low clearance areas.

- Technology Center Testing
    - Test maneuverability and determine robot constraints.
    - Develop and refine photo capture system.
    - Generate lab autowalk path.
    - Capture photos with Spot autowalk, and human operator.

At the jobsite, we wanted to see how Spot would handle real construction obstacles. We also wanted to test how well Spot could document a site compared to a human operator. We ran several trial runs, comparing the time it took to capture an area with Spot, vs. a human operator. We also compared the quality of photos captured by Spot vs. a human. While onsite, we talked with several craft workers to gauge their response to Spot.

- Jobsite Testing
    - Put Spot to the test with real construction obstacles.
    - Generate jobsite autowalk path.
    - Capture photos with Spot autowalk, and human operator.
    - Evaluate craft response to Spot.

Spot on Site

After testing concluded, we evaluated the outcomes of testing.

- Human vs. Spot
    - On average, Spot took twice as long to walk the same path. Due to the longer walk duration, Spot captured significantly more photos than the human operator which allowed for more robust evaluation of housekeeping issues.
    - The quality of photos captured by Spot vs. a human operator were essentially the same; however, the perspective and quantity of photos varied greatly. All of Spot's photos were captured at a lower vantage point, making it difficult to see above tables or equipment, and difficult to tell what was inside bins. On the other hand, the lower vantage point made it easier to see underneath tables and equipment.
- Navigating Obstacles
    - Spot expertly navigated terrain in the lab space and construction site.
    - There was a strong correlation between where spot had issues and where we saw housekeeping issues. For example, open exposed holes, large trip hazards,

and messy cords all proved to be issues for Spot and would be marked as housekeeping issues onsite.

- Mission Repeatability
    - When returning to the jobsite after 2 months, Spot was unable to complete the autowalk without assistance in areas where we had new material storage and in areas with significant site changes. If we had been able to test Spot onsite every day, we could have determined exactly when a site condition changed enough to impact Spot's ability to navigate the space and successfully complete the autowalk.
    - Keeping construction walk paths clear and increasing frequency of fiducials increased Spot's ability to repeat missions onsite, however further testing is needed to conclude the degree of repeatability across the lifespan of a project.

Additional Resources

About the Speaker

ENR 2022 Top Young Professionals at Skanska

Reality Capture and Analysis: Value Today and Possibilities of Tomorrow – Panel Discussion

Women in Construction Tech – Panel Discussion

About Skanska

Innovation at Skanska

Skanska USA

Project Origin

Call for Proposals

More about the Call for Proposals

Autowalk Support

Creating a Robust Autowalk Mission Framework

Getting Started with Autowalk

Autowalk Mission Replay Options

Using Autowalk for Site Inspection