Spot on Site

Maximizing Jobsite Robotics for Evaluating Housekeeping

Brooke Gemmell
Emerging Technology Manager | Skanska
Brooke Gemmell

• Work:
  o Emerging Technology Manager
  o Skanska USA Building
  o Portland, OR

• Education:
  o Civil & Environmental Engineering at University of California, Berkeley
  o Sustainable Design Minor
Project Origin
August 2021: Call for Proposals

True collaborative approach leveraging resources from all parties

- **Boston Dynamics** - Spot hardware and expertise
- **Autodesk** - Technology Center Lab Space and technical support
- **Skanska** - Construction experience and jobsite testing opportunities
Ideation Session

- Skanska hosted 2-day workshop to ideate and prioritize use cases

- Team chose **Housekeeping** as the primary use case
  - Current process is inconsistent, infrequent, and takes a lot of time
  - Housekeeping is the heartbeat of the jobsite – it is so much more than just keeping your site clean
Project Goal
Automate housekeeping inspections and analysis to improve jobsite housekeeping and safety record over time.
Can we....

- Automate capture of photos to be used in housekeeping analysis?
- Automate analysis of housekeeping photos?
- Successfully navigate around a jobsite with Spot?
- Consistently repeat autonomous Spot missions over time?
- Engage craft workers onsite and educate them about Spot?
- Improve housekeeping and safety record over time?
Solution
Solution

Plan  Walk  Capture  Upload  Analyze

- Plan
- Walk
- Capture
- Upload
- Analyze
Testing
Dual Approach

- **Testing**
  - Capture: Human vs. Spot
  - Analysis: Human vs. Computer

- **Technology Center Testing**
  - Learning and developing processes

- **Jobsite Testing**
  - Testing in real-world conditions

- **Iterative Approach**
  - Revisit testing locations after two month to test repeatability
Capture
Capture

- Human Method
  - Manually walk site using StructionSite Videowalk, holding 360 camera on monopod

- Spot Method
  - Autonomously walk site using Structionsite Videowalk, with 360 camera fixed on Spot
Capture Criteria: Human vs. Spot

- Capture Speed
- Photo Density
- Photo Quality
- Impact to Site
- Risk of Incident
- Cost to Deploy
## Capture: Human vs. Spot

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Human</th>
<th>Spot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture Speed</td>
<td>✓ (2x faster)</td>
<td>X (2x slower)</td>
</tr>
<tr>
<td>Photo Density</td>
<td>X</td>
<td>✓ (2x photos)</td>
</tr>
<tr>
<td>Photo Quality</td>
<td>✓</td>
<td>✓ (more consistency)</td>
</tr>
<tr>
<td>Impact to Site</td>
<td>✓ (craft engagement)</td>
<td>X (distracting)</td>
</tr>
<tr>
<td>Risk of Incident</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td>Cost to deploy</td>
<td>✓</td>
<td>X (5x human)</td>
</tr>
</tbody>
</table>
Maneuverability

- Navigating Obstacles
  - Spot expertly navigated terrain in the lab space and jobsite
  - There was a strong correlation between where spot had issues and where we saw housekeeping issues
- Stairs
- Pipes
- Metal Decking
- Rocks
- Steep Hills
- Tight Spaces
- Ladders
- Mud
- Empty Offices
Repeatability

- Repeating Autowalks
  - Spot was unable to carry through with the mission in areas with significant material storage and site changes
Housekeeping Analysis
Housekeeping Analysis

- Human Method
  - Human review all photos and flags issues
Housekeeping Analysis

- Computer Method
  - AI reviews all photos and flags issues
  - Human reviews flagged photos
Method: Review 360
Video: Walk photos on Newmetrix using "Housekeeping" SmartTag

Review Time: ~10 s per photo

Photos Tagged with Housekeeping Issues (High Confidence):
11 out of 378 photos (2.9%)

Valid Issues:
11 out of 11 photos (100%)

Unique Issues:
5 issues out of 24 identified manually (20.8%)
Analysis Criteria: Human vs. Computer

- Review Time
- Issues Identified
- Valid Issues
- Unique Issues
Capture: Human vs. Computer

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Human</th>
<th>Computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review Time</td>
<td>X (45 min)</td>
<td>✓ (&lt;2 minutes)</td>
</tr>
<tr>
<td>Issues Identified</td>
<td>✓ (24 issues)</td>
<td>X (11 issues)</td>
</tr>
<tr>
<td>Valid Issues</td>
<td>✓ (100%)</td>
<td>✓ (100%)</td>
</tr>
<tr>
<td>Unique Issues</td>
<td>✓ (24 unique issues)</td>
<td>X (5 unique issues)</td>
</tr>
</tbody>
</table>
Craft Response to Spot
Craft Response to Spot

- Somewhat distracted during Spot walks
- Need to clearly communicate what Spot’s job is
- In general, lots of excitement and interest in Spot!
Research Findings
Can we....

- Automate capture?
  - Almost! StructionSite/Spot integration is needed to fully automate.

- Automate analysis?
  - Yes! However, the automated analysis is still rudimentary and only identified 20% of issues.

- Navigate the site with Spot?
  - Yes! Spot expertly navigated the jobsite, but struggled with clear partitions, caution tape, and areas with housekeeping issues.

- Repeat Autowalks?
  - It depends. Site changes impact Spot's ability to repeat autowalks.

- Engage craft workers?
  - Yes! High interest and engagement from craft workers.

- Improve housekeeping and safety record?
  - We were unable to evaluate this due to lack of daily jobsite testing.
Big Thanks!

**Skanska**
- Evan Reilly
- James Mustico

**Boston Ideation Session Attendees**
- National Emerging Tech Team
- Belmont High School Team
- 380 Stuart St Team

**Autodesk Technology Center Staff**
- Stephanie Pender
- Adam Day
- Kristen McClary
- Joe Aronis

**Autodesk Research Team**
- Angie Foss
- Denise McCarty
- Haley Cormier
- Sophia Zelov
- Alana Mongkhounsavath
- Zainab Yaqub
- Lily Prasuethsut
- Mei-yen Shipek

**Boston Dynamics**
- Brian Ringley and Team