



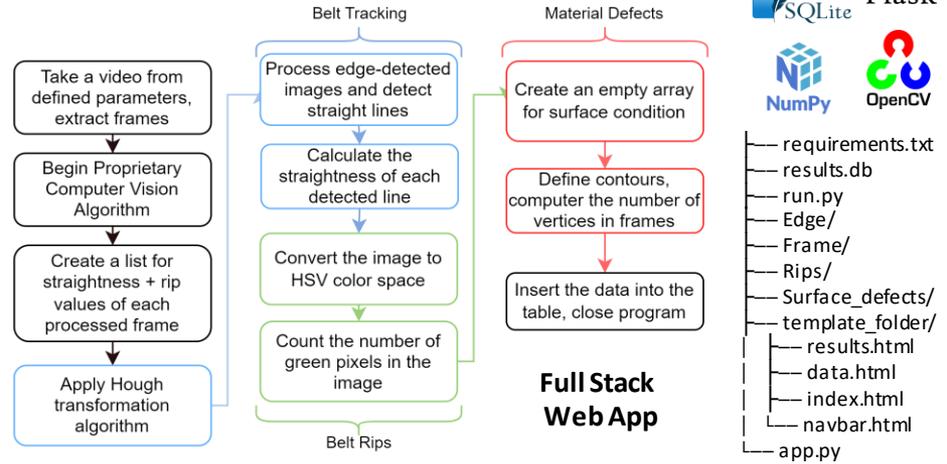
## Background

## Hardware & Software

Amazon houses on average 11-22 miles of conveyance belts per fulfillment center, the belt failure increases downtime and costs millions of dollars.

- Belt Rips**
  - A **belt rip** occurs when the belt separates or tears apart, causing a complete belt failure
  - Package damage or other abrasions can cause rips and tears in the belt
  - Splices** are staples joining a belt together, which are susceptible to damage and can become weak points that may result in a rip
- Belt Tracking**
  - Belt tracking** is when the belt veers off-center and rubs against the conveyor frame or other components, causing premature wear and damage to the belt
- Material Defects**
  - Misaligned belts account for 15% of all mechanical failures in Amazon's conveyance systems
  - Material defects** such as cuts, gouges, and tears can cause belt failure

<b>Initial Experiment</b>	 XBOX Kinect	
<b>Testing Hardware</b>	 Raspberry Pi 3B	 Logitech Camera
<b>Final Design</b>	 NVIDIA Jetson Nano	 USB 1080P Wide Angle

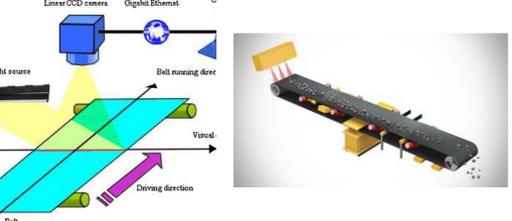


## Scope of Work

- ✓ Detects rips, material defects, alignment
- ✓ Affordable (BOM <= \$400)
- ✓ Non-Invasive
- ✓ Recommend maintenance from KPIs

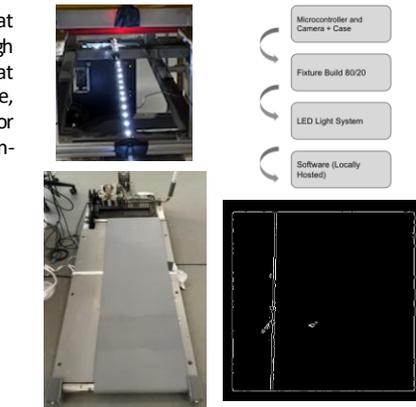
## Existing Solutions

Existing solutions for conveyor belt failure mode detection at Amazon sort centers mainly rely on regular walkthrough inspections by maintenance personnel. Other systems at Amazon, such as sensors that detect changes in temperature, vibration, or motor current, do not monitor belt health or generate a predictive maintenance report utilizing vision-based software

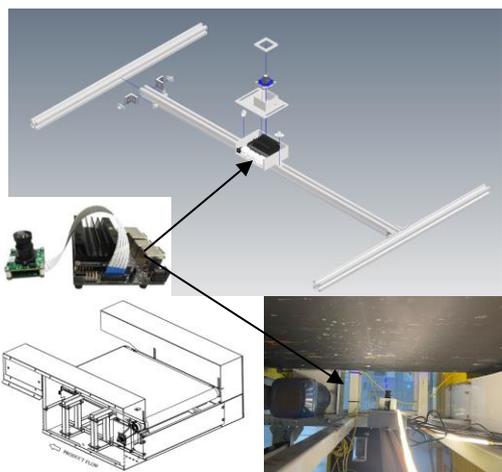


## Testing

Camera Vision	Pros	Cons
ELP 2.0 MP USB Camera	<ul style="list-style-type: none"> <li>120fps</li> <li>Inexpensive: \$60+</li> <li>Wide Angle Lens</li> <li>Ease to Use</li> <li>Compact</li> </ul>	<ul style="list-style-type: none"> <li>Only 720P at 120fps</li> </ul>
NVIDIA Jetson Nano	<ul style="list-style-type: none"> <li>High Processing Power</li> <li>Many different ports</li> <li>Small Footprint</li> </ul>	<ul style="list-style-type: none"> <li>Can be difficult to use</li> <li>Expensive</li> <li>Very Slow</li> </ul>
Raspberry Pi 3B+	<ul style="list-style-type: none"> <li>Small Footprint</li> <li>Inexpensive</li> </ul>	<ul style="list-style-type: none"> <li>Requires a PC</li> <li>Low frame rate and low resolution</li> </ul>
Logitech Desktop External Camera	<ul style="list-style-type: none"> <li>Inexpensive</li> <li>Easy to use</li> </ul>	<ul style="list-style-type: none"> <li>Bulky</li> <li>Low resolution</li> <li>Extremely Expensive</li> </ul>
Kinect 360 Camera	<ul style="list-style-type: none"> <li>Free</li> </ul>	<ul style="list-style-type: none"> <li>Low resolution</li> </ul>
High Speed Camera Attachment	<ul style="list-style-type: none"> <li>Best framerate</li> <li>Best Resolution</li> <li>Compact</li> </ul>	<ul style="list-style-type: none"> <li>Extremely Expensive</li> </ul>



## Final Design



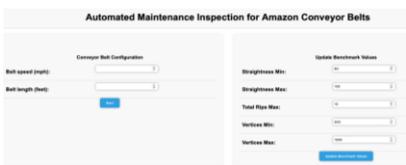
**Vertical tracking**  
Belt tracking within predetermined margin.

**Surface Condition**  
Material (amnesty), belt surface condition

**Belt Rips**  
Rips are illuminated by an isolated light beam between the belt

**Locally hosted website**  
easily accessible, informative, configurable belt portal

**Automated Maintenance Inspections**  
Alerting technicians of major defects, with delicate reminders of minor defects.



**Predictive Maintenance Report**

The belt is in bad condition and requires maintenance.

Metric	Value	Benchmark	Performance
Average straightness value	9.738206374955882	80-100	Bad
Total number of rips	0	less than 10	Good
Average overall surface condition	31.78181818181818 vertices	500-1000 vertices	Bad

**Performance**

ID	Average Straightness	Max Value	Average Number of Vertices	Overall Stability	Date	Time
1	35.20261111111111	95.5	0.1660667721440078	0.0000000000	2022-03-05	17:18:00
2	0.0	0.0	0.0	0.0	2022-04-05	14:01:02
3	0.0	0.0	0.0	0.0	2022-04-09	13:04:23
4	0.0	0.0	0.0	0.0	2022-04-09	13:12:52
5	0.0	0.0	0.0	0.0	2022-04-09	13:13:08
6	0.0	0.0	0.0	0.0	2022-04-09	13:13:18
7	0.0	0.0	0.0	0.0	2022-04-09	13:18:14
8	0.0	0.0	0.0	0.0	2022-04-09	13:20:28

Results are saved to a database after auto and manual run. Able to store 5+ year of data