Automating Defect Detection for Blind Textile Workers

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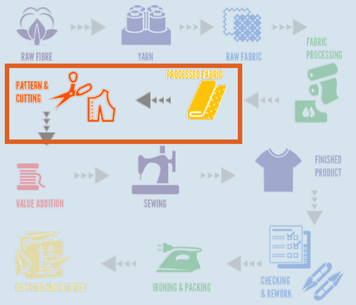
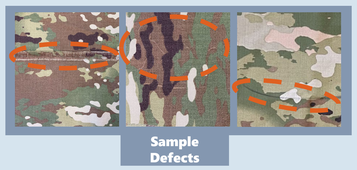
Introduction

Traditionally, blind operators in a fabric patterning and cutting facility relied on sighted operators to perform quality inspection, ensuring that defects such as cuts, tears, and misprints are absent from the final product. Our team developed a custom mounting solution to deploy a **state-of-the-art** neural network to automate detection.




Sample Defects

"[It will] save us a lot of time searching for the smaller defects."

Our solution not only empowers blind operators with more autonomy in the workplace, but also significantly enhances the facility's productivity by reducing manpower needed for quality assurance. Utilizing the high-performance, low-footprint NVIDIA Jetson AGX Xavier2, we designed all required control sequences to ensure seamless integration and operation.

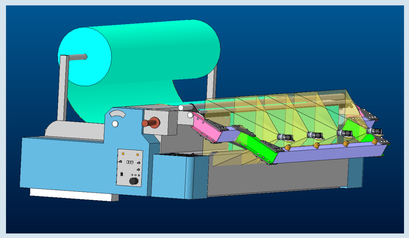
Specs:
- 512-core NVIDIA Volta architecture GPU with 64 Tensor Cores
- 32 TOPS AI Performance
- 105 mm x 105 mm footprint
- 2x NVDLA Engines

Existing market solutions are cost-ineffective and incur additional expenses in subscription services for upkeep and maintenance. We present a competitive and **cost-effective** alternative, delivering comparable performance at a fraction of the cost.

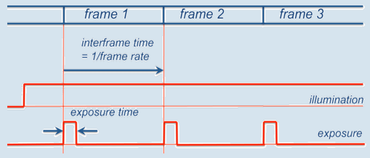
"I can forget that [the solution] is even there."

"It's convenient to finally have records of the defects"

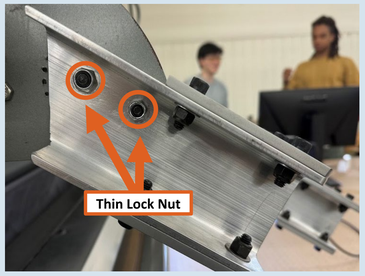
Mounting and Build



Constructed primarily of Multipurpose 6061 Aluminum U-Channels, our mechanical mount offers excellent strength-to-weight ratio and high moment of inertia. These properties reduce weight without sacrificing stability, and effectively dampen vibrations. Lock nuts were also used to prevent loosening of fasteners due to cyclic vibrational load.

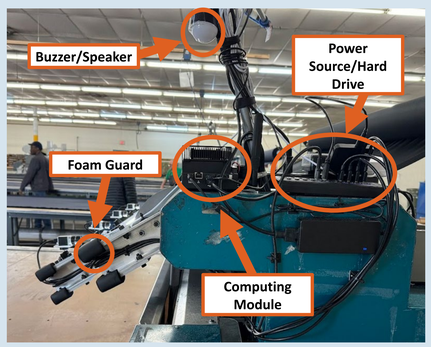


Our team conducted extensive user studies to form our system requirements and gather operator feedback. Utilizing CAD software such as Creo and SolidWorks, we then designed a mechanical frame to optimize operator comfort and ease of use.



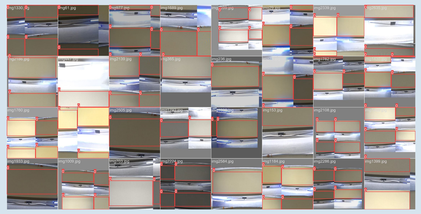
To ensure optimal image clarity, we selected the Basler Ace 2 camera[1] with a high-resolution auto-exposure sensor. This allows for accurate capturing of minute defects despite vibrations.

Challenged with limited mounting options, our team successfully created a design prioritizing seamless integration with operator workflow. The frame's inward-turning arms allow for unimpeded fabric handling from operators. Foam guards were added to exposed corners for operator safety, and extensive cable management was performed to increase aesthetics and to ensure that wiring would not impede workflow.



Detection and Visualization

Our model reaches detection rate reaches on average for defect detection on **moving** fabrics **2.3ms**

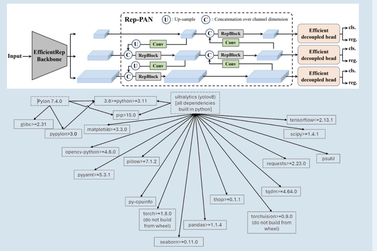


Preparation

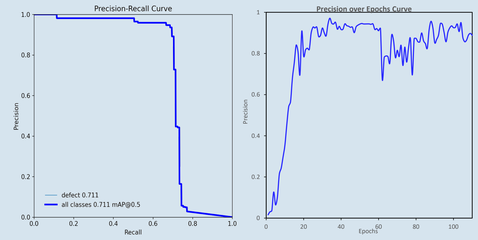
After manually labeling the images, Yolov8 carries image augmentation (MixUp, Mosaic, Compose, and Mix Transform) to diversify the data set.

Training

We then randomly separate the dataset into train and validate. Through an iterative process using GPU, we monitor to prevent overfitting and underfitting.



Validating



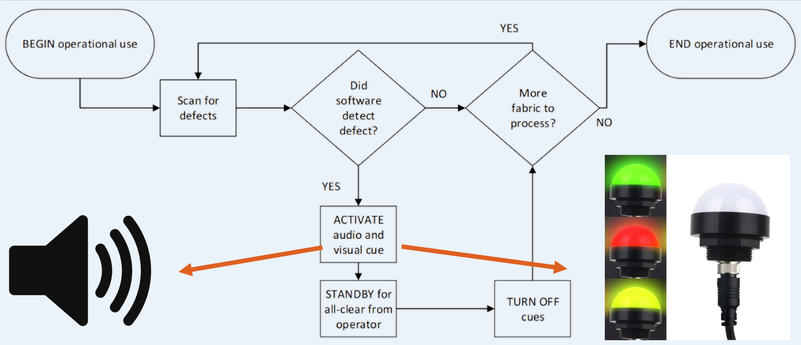
Precision reflects and minimizes the rates of a false detection.

Recall reflects when a defect is missed during validation.

Solution Requirements

ID	Requirements
BIS-1	The defect detection system should be able to scan the full length (up to 64 in) and span of the fabric roll.
BIS-2	The solution must be compatible with the manual fabric spreader.
BIS-3	The solution must not impede the workflow of visually impaired operators.
BIS-3.1	The solution must not obstruct operators when replacing spent fabric rolls.
BIS-3.2	The solution must not obstruct operators at any point during their fabric spreading process.
BIS-3.3	The solution must be responsive enough to allow for the operation of the spreader at normal speeds, as set by operators.
BIS-3.4	The solution must not exceed 25 pounds when assembled on the spreader.
BIS-4	The solution must have detailed documentation for operations, maintenance, debugging, and configuration.
BIS-5	The solution must be able to detect as many defects as possible from the following list: misprinting (including shifted mirage print, and thread print), knots, loose thread, tear, pinhole, stitching, imprint from tight rolling of fabric roll, fabric overlap, dye run, large hole, tape from manufacturers pre-labeling defects.
BIS-6	The solution must provide feedback to the operator when a defect is detected.
BIS-7	The solution must be able to withstand indoor factory environmental operation conditions.
BIS-7.1	The solution must be able to withstand vibrations caused by normal operations, with a reasonable life cycle.
BIS-7.2	The solution must be able to withstand reasonable physical contact for operations (cyclic loading, for instance) and accidental impacts from operators and operate for a reasonable life cycle.
BIS-7.3	The solution must be able to withstand deterioration due to any heat produced by or introduced to the system by any electronics during normal operation.

Process Flow



Next Steps

As new fabrics are introduced to the fabric facility, our neural network will need to be trained on novel fabric types. This entails labeling defects with open-source software.

To ensure system lifespan, a case should be developed to package all electronics including USB expansion devices. There should also be a copy of the quick-start guide provided in braille attached to the spreader.

References

1. AG, Basler. a2A2590-60ucBAS | Basler Product Documentation — docs.baslerweb.com. https://docs.baslerweb.com/a2a2590-60ucbas.
2. NVIDIA. NVIDIA Jetson Xavier Development Kit. https://tinyurl.com/295v3voy.
3. Rasheed, Aqsa et al. "Fabric Defect Detection Using Computer Vision Techniques: A Comprehensive Review". In: Mathematical Problems in Engineering 2020 (Nov. 2020). Ed. By Sajad Azizi, 1–24. ISSN: 1024-123X. DOI: 10.1155/2020/8189403.

Acknowledgements

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