AI Based Real-Time Video Analysis of Molding Ejection

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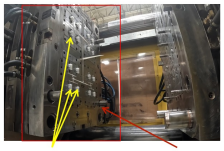
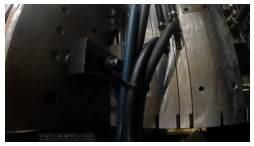
Mold Injection and Ejection



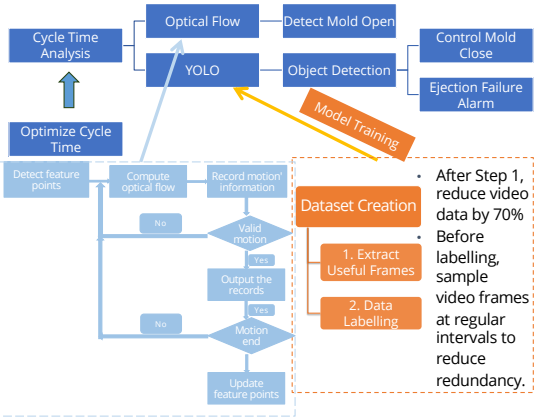
Open Status



Close Status

- Mold ejection happens between mold opens and closes and the ejection cycle time is determined by mold opening time and mold closing time
- **Objectives**:
- 1). Optimize ejection cycle time to the theoretical minimum
- 2). Achieve real-time (inference speed 60+ FPS) control in case ejection failures happen
- 3). A standardized model training and prediction pipeline
- **Current solution** (Problem): Manual observation (not accurate and time-consuming)
- **Our approach**: Using Optical Flow and object detection algorithms (YOLO) to precisely capture mold opens and determine the mold close time

System Design

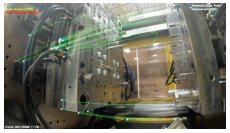


- After Step 1, reduce video data by 70%
- Before labelling, sample video frames at regular intervals to reduce redundancy.

Determine Mold Open - Optical Flow

Innovative Design:
- Automatic update of feature points
- Filter valid motion based on the duration

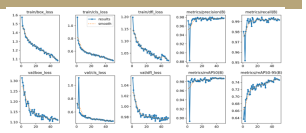
Application Value:
- Intelligent recognition of molds open
- Save computational resources
- Adapt to different detection tasks(automatic detection)



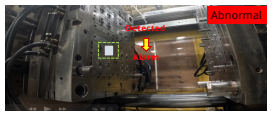
Start to Open

Determine Mold Close and Ejection Failures - YOLO Detection

- Training costumed YOLO model
- Mean average precision (mAP) 98.8% at 0.5 confidence
- **Two-factor** detection for ejection failure
- **Judgment conditions for mold close**: All molded parts are ejected and molded region is clear

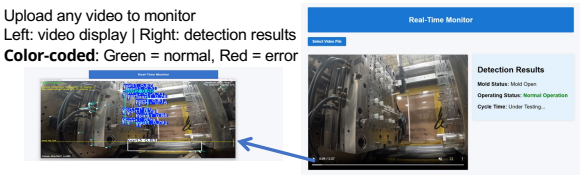


- **Factor 1**: When the mold is fully opened, count the total number of molded parts detected (to ensure no parts are embedded into the molding machine)
- **Factor 2**: Check if one or more objects can be detected consistently

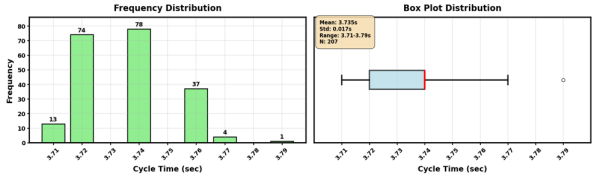


Real-Time Control - User Interface

- Upload any video to monitor
- Left: video display | Right: detection results
- **Color-coded**: Green = normal, Red = error

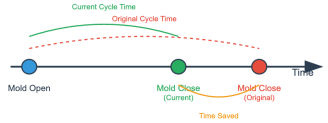


Results - Statistical Analysis and Business Value



- In this project, we implemented the algorithm for two part numbers, and statistically analyzed the calculated cycle time.
- The above charts can help workers make decisions about selecting suitable ejection cycle time for molding machines.
- We also compared the ejection cycle time before and after applying the proposed solution. The comparison table is shown below.

Part Number	Before (s)	After (s)	Improvement (s)
No.1	6.00	3.77	2.23 (37.16%)
No.2	3.83	2.52	1.31 (34.20%)



- The data showed that the proposed solution significantly reduced the total cycle time, including injection time, by 5%,, enabling over 320+hours of production.
- By a conservative estimate, the proposed approach will enable an annual revenue of $160,000, which is calculated by the following formula:

Future Work

- Use high-speed camera instead of regular camera to better capture the molded parts falling process
- Add Multiple Object Tracking (MOT) algorithm to help analyze the trajectory of each molded part
- Consider introducing perspective transformations to improve MOT

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