TECHNICAL OVERVIEW

AUTOMATE 3D PRINTING WITH ARTIFICIAL INTELLIGENCE USING PRINTWATCH

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OVERVIEW

As 3D printing becomes increasingly popular for Manufacturing and Rapid Prototyping, managing larger fleets of printers becomes increasingly difficult and complex. The idea of a system that schedules print jobs, prints the parts, and repeats continuously without any human intervention is exciting. In reality, many challenges exist for such a control system. For example, closed-loop visual feedback of the print job is required so the printer does not waste time and material on a failed or defective print. Machine Learning (ML) and Computer Vision Algorithms (CVA) are effective tools for solving this issue. In this overview, we will explore the challenge of closed-loop visual feedback and how to approach it.

3D printing operations are classified into 3 distinct groups that are all affected by the lack of closed-loop feedback and benefit from the implementation of it to different degrees.

Individuals print in moderation on a small scale. They must remain in proximity to the printer while it is active to verify the print job isn't defective. They benefit primarily from the peace-of-mind provided by a monitoring system that enables them to leave the proximity of the printer.

Print farms print continuously on a medium scale. They have a technical person on-site to manage the printers. They benefit from the material and time savings that translates to business revenue and operating efficiency.

Industrial operations print on a large scale and require high precision and quality. Similar to print farms, they benefit from the material and time savings that translates to business revenue and operating efficiency.

CHALLENGES

The amount of dynamic factors in 3D printing present a few challenges when automating the process:

1. Defects begin to develop that render the entire print as waste. Failure to catch the defects results in wasted time, material, and potential damage to the machine.
2. Machines wear over time and require maintenance. When a machine eventually breaks, it results in damage and downtime.
3. Print beds need to be reset and prepared each time a new print is started. Failing to do so can result in a failure for the print.
4. Quality of the printed parts needs to be assessed before being sent to customers or deployment. In many cases, a thorough visual inspection is required in addition to measuring the tolerances of the part according to the specification.

PRINTWATCH

Individuals and organizations can address the challenges of automating 3D printing with PrintWatch, an API that provides visual closed-loop feedback using Machine Learning models that detect 3D print defects and failures. The API monitors print jobs in real-time for defects and failures and takes preventative actions set by the user, such as sending notifications to the operator, pausing or stopping the print, turning off the extruder or print bed heaters, and adjusting print settings such as the extruder and bed temperatures or maximum velocity and acceleration.

The PrintWatch API Client enables individuals, print farms, and industrial operations to easily implement visual monitoring to

their 3D printing operation by integrating with popular platforms such as OctoPrint and Klipper.

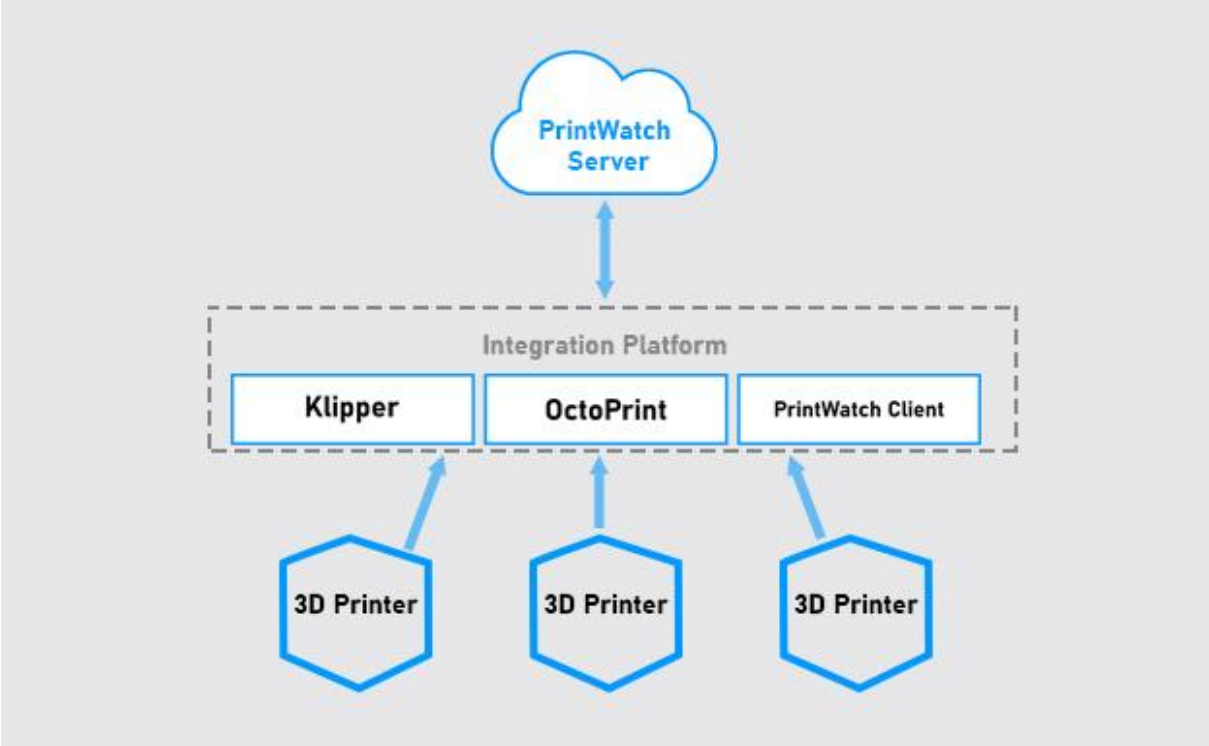

Figure 1: PrintWatch Integration Architecture

Figure 1 shows how PrintWatch interacts with the common integration options when using the API. PrintWatch is available to run on a dedicated container or edge device when increased functionality and security is required.

PrintWatch helps individuals and organizations automate their 3D printing operations with the following features:

1. **Detecting and classifying defects and failures in dynamic conditions:** While a 3D print job is running, PrintWatch is watching the camera feed and running it through Machine Learning models that determine the locations and types of defects present. The models work

for any plastic materials in any color and size, in dynamic lighting conditions, in dynamic backgrounds, and on any printer.

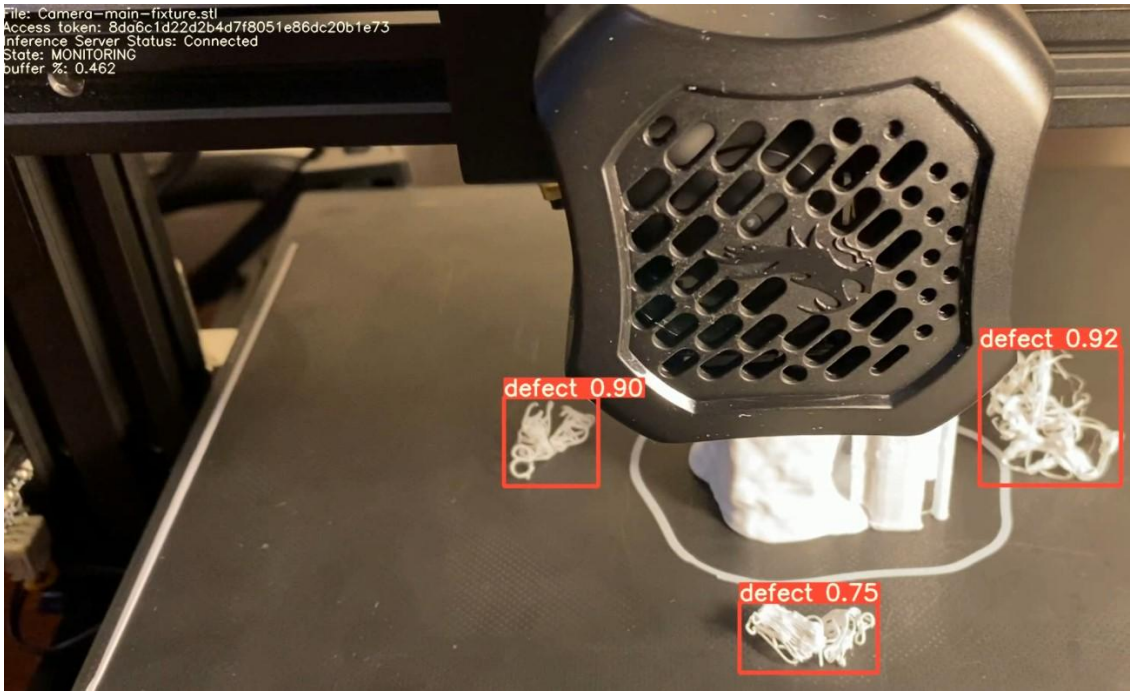

Figure 2: PrintWatch detecting 3D print defects in real-time

2. **Passive Anomaly Detection:** Machine Learning models learn the baseline behavior of the printer and produce flags when anomalous behavior is observed. This allows individuals and organizations to schedule preventive maintenance and reduce downtime.
3. **Automatic Queuing Check:** A Machine Learning model will check if the print bed is clear and ready for a print. This allows printers to continuously print from the queue without human intervention.
4. **Live Quality-Control and Quality-Assurance*:** While a 3D print job is running, the quality of the portion of the part that is printed can be assessed using Machine Learning models. Defects such as under-extrusion,

** Feature in beta trials*

overhang, stringing, and blobbing on the part are all identified and localized. The QC/QA ML models work for both plastic and metal 3D printing.

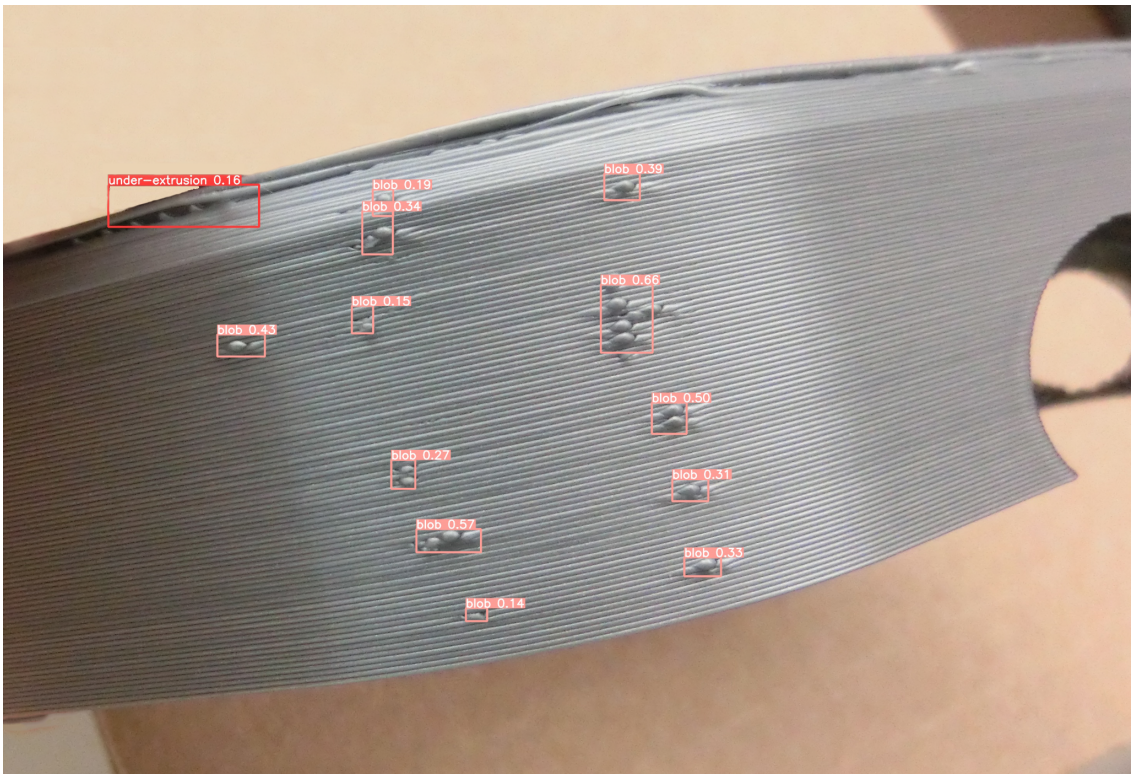

Figure 3: PrintWatch detecting quality-control related defects

GETTING STARTED

Getting started is easy and requires minimal technical expertise.

OctoPrint or other supported platform

1. Install the PrintWatch plugin via the Plugin Manager or Plugin Repository.
2. Restart OctoPrint.
3. Follow the Quick-start guide to setup your PrintWatch settings.

Custom Integration

1. Pull the PrintWatch client repository from GitHub.
2. Follow the Custom Integration Example document to run the basic example.

Business Integration

In some cases, a more customizable and fully-integrated option is required. Contact the printpal.io Engineering and Architecture department at: lebiedzinskip@printpal.io

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