Printed Circuit Board Automatic Optical Inspection (AOI)

Ploopy Corporation is a designer and manufacturer of open source consumer electronics. We make things like mice and headphones, with plans for many more. We design all of our own products, and do much of the manufacturing, including in-house electronics assembly. As such, we're always improving our processes, and we would like to implement an Automatic Optical Inspection (AOI) machine for our assembly line. This machine will examine assembled printed circuit boards for missing or incorrectly placed components, flagging any errors. When done before the board is reflow soldered, the cost of correcting assembly errors is very low, which makes this step very valuable.

While AOI machines exist in industry and have for some time, we are looking to implement an open source one both as a contribution to the community to which we belong and also to live our principles. This work would be distributed under a combination of the CERN OHL-S and GPLv3 licenses, which are both open and copyleft. Our hope is that a community (and perhaps even future students) will continue to build on this work, uplifting the entire practice of making open hardware.

For this project, Ploopy will provide hardware (camera, PC, lighting and machine chassis prototype) for testing and development, as well as sample boards as necessary. The prototype design will have a frame to carry an inspection area, PC/screen/mouse/keyboard and camera. Initially, we envision that an operator will place the board inside the examination area, trigger an inspection via the GUI and then look at the results on the screen.

Aside from the constraints that are baked into the physical design and expected usage paradigm, we're pretty open about how the solution is implemented as long as it meets the requirements outlined below.

Requirements:

- Software shall run on either Windows 10/11 or a Debian-based Linux distribution (Ubuntu is preferred). PC hardware can be purchased to suit, though our preference is for SFF (small form-factor) PCs to minimize machine physical footprint; these do not generally have discrete GPUs.
- A GUI (screen + mouse/keyboard) shall be provided to:
- Set up new board designs.
- Examine boards and highlight any errors found.
- The training process should require as little training/configuration data as possible to minimize the setup cost for new boards. Our hope is that fewer than 10 "golden sample" boards will be needed to set up a new board for optical inspection.
- The false negative rate (percentage of boards that are deemed error-free but in fact have errors) should be <1%, in keeping with the generally accepted figure for a "good" production line.
- The false positive rate (percentage of boards that are deemed to have an error but are in fact error-free) should be <2%, to minimize waste of operator time and maintain operator confidence in the system.
- The processing time to check a board should be <2s; if this figure is exceeded on the test platform, the design used must scale well (i.e. get faster) with the addition of more powerful computing hardware.

This is a continuation of a project started in Winter 2025. The extension of the project will involve some of the following requirements

- Improving the board-level classification. This may involve hyperparameter tuning, image transformation, generating synthetic training data, and a way to automate this process
- Component-level classification & object detection.

We're looking for a team of 2-3 students to work on this project, because most people do better work when they do it together. However, if you're an individual who feels a particular affinity for the project, we'd still like to hear from you!

If this project interests you, please send an email to jy.lam@utoronto.ca with answers to the following questions:

- Why are you interested in this particular project?
- What other work have you done that makes you a good fit for this project? Links to demos are great!

Answers can take any form, but it doesn't have to be long -- 100-200 words is more than enough. CVs are okay but not necessary, and links to your previous work are welcome (bonus points if you have a GitHub page).