MTRL 466- Sensing Failure Weekly Meeting Minutes

Date: October 16, 2019 - 3-4pm

Room: FF 308 A

Week 7: Review of Midterm Report and Next Steps

Leader: Isabela

Secretary: Sofia

Attendance:

Individual	In Attendance
Catherine Greenwood	Y
Jenna Moledina	Y
Clement Asiedu-Antwi	Y
Isabela Taketa	Y
Aleisha Cerny	Y
Sofia McGurk	Y

Agenda:

1. Status Update
2. Review of main parts of the report
    a. Objectives
        i. "The objective of this project is to create a proof of concept that will minimize material waste and maximize efficiency by sensing defects and stopping the print when a defect is detected."

Chad: Objective should be possible to show quantitatively how much was improved
Chad: What is maximizing efficiency? Avoid fuzzy concepts- need clear stuff such as minimizing waste. Do we need to maximize efficiency?

    b. Constraints
        i. "The requirements for the solution are that it has to be non-contact, so it won't interfere with print quality, has to cost less than the printer itself (less than $400) since it is an add-on to the printer, and has to be able to

sense defects and stop a print that may potentially lead to a “spaghetti monster” type of defect”

Chad: Still more he can think of? Constraint is compatible with many different types of printers. Our constraint is to use it on a Prusa. Usually can write lots of constraints- we should look into adding more.
Chad: Objective minimize waste- do this by assuming FDM, general enough to use on lots of printers. Constraints help to narrow the focus.

c. Line Laser

i. “Laser line scanning technology is an accurate, contactless and fast method currently employed in the inspection of the localization of surface abnormalities on large surface areas [C3]. This technology is widely used in the manufacturing industry because of the low weight and compact size of the scanners, allowing easy integration with robot systems [C3]. **Figure x** below shows an example of a laser line scanner used in industry. Besides purchasing an off the shelf scanner which can be expensive, this method provides the option to create a custom scanner with a camera, line laser and a filter.

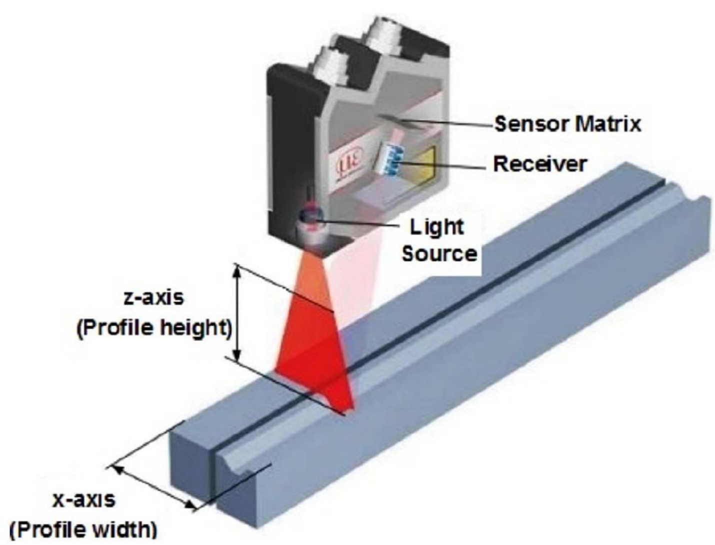

Figure x: A Micro Epsilon Laser Line Structure [C3]

Laser line scanning technology works on basic geometric optical principles to accurately detect surface abnormalities (defects). Simply put, a laser line is projected onto the surface being inspected and the reflected light is picked up by the camera for analysis. From the original CAD model, the average position of the laser line can be determined as a function of height (layer number). This position is then compared to the real time position of the laser to determine if there is an undesired shift. The change in the z-direction on the print surface translates to the change in y on the 2D image received by the camera. For this method, defect detection is classified in two ways. Points of interest; those points that deviate from the from the average by more than 0.4mm and if the reflected line is not in the same position as calculated from the CAD model.

Benefits and Downsides

The laser line system presents advantages mainly in terms of speed. The cost of custom equipment is also affordable and can be justified considering the cost of the printer. It is a fast, non-contact method capable of achieving high resolutions. The simple commercial scanner shown above has 1280 points in the line profile [C3]. For our application in detecting when to stop the FDM printer based on a significant defect, this precision will suffice. Also, due to the fact that this is based solely on geometric optical principles [C1], it is relatively easier to understand and apply as compared to the laser speckle and this will significantly help when troubleshooting.

However, there are also some disadvantages to this system which can lead to inaccuracy and uncertainty. Surface reflectivity issues are the most prominent because of the optical nature of the technology. Other issues are environmental effects such as light conditions or dust, shadowing might also occur when a part of the object or printer lies in the path of the projected laser line to the camera [C3]."

Chad: Good image to depict line laser.
Chad: Reads well for the line laser. We want to go from qualitative stuff (what we have done so far) to make this more quantitative. Need to look for numbers. Start to become more specific, look into parameters.

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Cat: If you shine a laser, when you hit a defect there is a space on the other side of an object. With a larger defect there would be a larger space. Simple geometry problem. Could help with scaffolding type objects.
Chad: One step back is how does previous methods work? Need to understand the technology before creating our own stuff. Look into in-line process monitoring in manufacturing.
Cat: Laser shine onto flat surface, laser comes straight back. If there is a bump the laser shines down and is deflected.
Chad: Want to have a camera at an angle. Measuring distance from laser line to deflected line.
Cat: Instant angle is equal to reflection law - law from high school physics
Chad: 2 perfect prints (solid block) should be able to measure the average height of each layer if you calibrate instruments well.
Chad: Similar triangles- look at the difference between lower layer reflection and higher layer reflection.
Chad: We can choose the angle of our camera
Chad: use pythagoras.
Chad: need to find out what the smallest value of x we can get - number of pixels.
Chad: want to measure as small a y as possible, can you fix x?
C: play with the angle
Chad: Why can't you do 180 degrees for the laser?
Chad: x is how big displacement of light on camera, y is the feature.
Chad: FOV changes when you move the camera up or down. If you move the camera closer means more pixels in a smaller area. Pixels stay the same even if the area changes. Explains why zoom feature makes the moon fuzzy but telescope is clear.
Chad: Before next week - simple explanation that explains geometry and variables of this laser. What do we need to set this up?
Chad: trade off with camera? 2 lasers instead of 1 at different angles? How to maximize ability to measure y (400 microns).
Chad: Starting point print solid blocks, or will it work just as well for lattice structure?
A: Starting point to just print solid objects build solution off of that then get more complex.
Chad: Get blue test object from Daan
Chad: Can make a test print with an open infill- shine laser on that. What do you see?
Chad: Start with simplest thing you can try to apply it to, then move on to more complex things .
Cat: What if our solution only works on simple objects? And if there is a different one that can be scaled?
Chad: this is what we have to figure out? Maybe we can recalibrate and go a different direction.
Chad: Thinks this process will be able to detect errors based off of the height measurement.
Cat: Measure points of height.
Chad: In theory should be able to get a full 3D x, y, z surface.
J: Need to dive into computer of things
Chad: Need to split tasks into: some people on the hardware side of things, the software side of things, socio economic.
Cat: Can we look at table of tasks?
Chad: It is up to us at what level and who is doing what?

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Cat: Do these items make sense?
Chad; Step before this- what is basic operating principle of this technology. Write out what we identified today. What are variables, how are you going to fix things? What is relation b/w theta, x and y. Want to know what the exact height of an object is- use a feeler gage. For us could use paper ~ 100 microns. Can we detect a shift in laser line for 4 sheets of paper. Must find spot that Line must be relative to defect? Perpendicular, Parallel, angle.
Cat: How do you analyse an image?
Chad: Pictures are a matrix with the scale from 1-255 (grey scale).
Chad: challenge is the laser has a thickness.
Chad: What are we going to measure? Detect an edge is easier. Find out where the edge is on a flat surface, then find out where that edge goes once you shine on a defect. Use something like python.
Chad: Leave interfacing to next semester- g code. Right now want to imagine we are the interface between computer and machine rn. Find a way to ID the defect but then we can stop the machine.
A: Can the user use the same computer to analyse data and run print?
Chad: In theory you can use 1 computer. Just need something that is looking at images, finding edge of line and calculating difference. Could use an arduino- basically uses python.
Chad: red laser measure defect and displacement of the line. How can you emphasize where the line is?
Cat: Filter
A: Use only R not G and B when processing image.
Chad: Do we need a filter?
Chad: Camera is $500, filter $140.
Chad: If we printed with red filter this would be an issue.
Chad: WIll this only work if we print in a color other than red? Could we use other color lasers to mitigate this?
Chad: Break project into 3 parts: Hardware, software and socio-economic
A: Filter camera and laser. Compare how much wasted vs how much save.
Chad: Think about sensitivity analysis- how much material do you have to save to get back environmental cost of the waste. Look into literature on 3D printing polymers and LCA.
A: Know % of material in each component and base it off of that.
Chad: Look at LCA on the camera and on the laser (previously). Need to do research on what is out there. If nothing else out there must base it off of the materials.
Chad: For next week: Slides on operating concept we just went through. Shine laser on things to see what happens. Look at software- edge detection in images (simple way to do this), and LCA what you found in previous literature in terms of laser and cameras. Will put together tutorials on python.
J: HW- laser, camera, physics. Software is computer and Life cycle is LCA and move onto economic if time or if needed?
Chad: Prusa is moving again.

d. Current Challenges
e. Discuss the chosen solution

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Action Items:

	Item	Assigned To
1.	Clarify objectives - drop maximize efficiency?	All
2.	Add more constraints- to narrow focus	All
3.	Understand how laser line projection works (slides). Make sure geometry and variables are explained. Previous solution: In line process monitoring- look into this.	All
4.	Get blue test object from Daan	All
5.	Look into previous work on LCA analysis on PLA 3D printing.	All
6.	Shine laser on different objects to see what happens: solid object vs open infill.	All
7.	Look into edge detection software for images	All

Next Meeting Time: Wednesday the 23rd from 4-5 pm.