Early Process Lighting Failure Detection via SDK Customization Script

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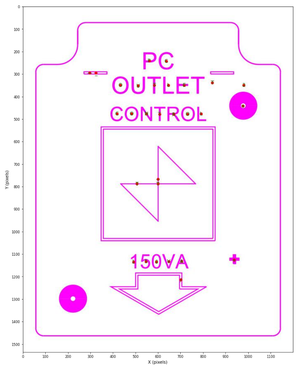
Background and Motivation

Important Definitions:
- PMM – Photometrica file
- DXF – Drawing Exchange Format (AutoCAD drawing file)
- Photometrica – The vision system that can manually detect lighting characteristics under its camera.
- Lightplate – an Aircraft Control Panel with illuminated text and symbols
- Area of Interest (AOI) – a set of pixels or area of a Photometrica capture which data is collected over.

There is a specification of luminance, chromaticity and contrast (further referred to as lighting characteristics) of the light that illuminates the text on the Lightplate. The goal of this project is to produce an automation script which integrates with the Photometrica Vision System to determine whether the light characteristics of an illuminated panel are within the specified range. The objective is to increase the efficiency of an operator and reduce waste by determining earlier in the manufacturing process if a Lightplate needs more paint, a full rework, or to be scrapped.

DXF to Image - Preparing DXF for Photometrica

- Due to the varying scales between the data in the DXF files and Photometrica, we employed image processing techniques to align the scaling between the two. Initially, we converted the DXF file into an image format, then applied HSV color space conversion for red region segmentation, detected contours within these regions, calculated bounding box coordinates, and annotated these coordinates visually on the image. This enabled us to identify the four corners of the item, corresponding to points in Photometrica, thus providing a foundational basis to scale any additional points as needed.
- Next, we were able to apply OCR (Optical Character Recognition) via the Tesseract library to extract bounding boxes around characters in an image. It then calculates the center coordinates of each character by using basic arithmetic to find the midpoint of each bounding box, adjusting for the image's height to account for the coordinate inversion typical in image processing. The resulting centers, which include the character and its computed central coordinates, are stored and returned.



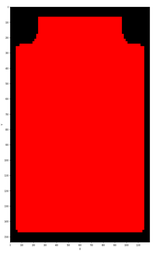


Figure 2: Image Processed DXF file

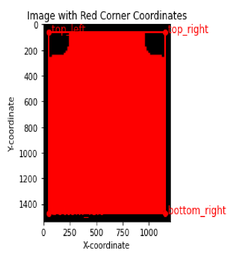


Figure 3: Image of Four Corners

EZDXF - Interpreting DXF Files

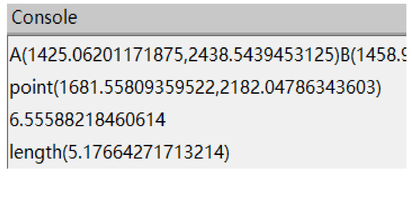
- Given the DXF files, we developed an algorithm to extract and interpolate all text and their coordinates. This algorithm parses the DXF files, capturing the text and storing it in a JSON file for further processing.
- The next step involved identifying three reference points for each character in accordance with military specifications. However, due to variations in fonts across different DXF files, the process for locating these reference points varied by character. To address this, we established individual databases for each font used, enhancing the scalability of our approach.

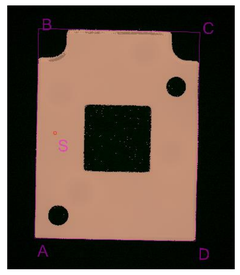

```
{
    "FONT": {
        "font":"Helvetic"
    },
    "A": {
        "height": 6.709653020546279,
        "width": 4.890814314869913,
        "center": [
            [
                22.197531332995606,
                53.13812759400252
            ]
        ],
        "coordinates": [
            [
                19.7591,
                49.7883
            ],
            [
                21.7431,
                55.0311
            ],
```


Figure 1: Helvetic Database in JSON

Integration of Photometrica - PMM Capture

- The goal of the Photometrica Integration is to develop and implement a script that seamlessly integrates the PMM with output of the DXF coordinate location scripts. This includes mapping DXF coordinates to physical Lightplate coordinates and ensuring the PMM software can accurately capture and analyze the required lighting characteristics.
- The coordinate system in AutoCAD and Photometrica are different. The origin in AutoCAD is the bottom left corner and Photometrica uses the center of the entire image as the origin, with the y-axis is inverted.
- The coordinates of the four corners of the Lightplate are automatically located through the findPolygon API. One corner is set as the zero point of the coordinate system then calculated the ratio between the two files to achieve seamless connection of the coordinate data obtained in the DXF.
- Once the ratio is found, the DXF coordinates are converted using the ratio and exported to a CSV file. This CSV file is imported to Photometrica to create AOI's which the lighting characteristic data is found.





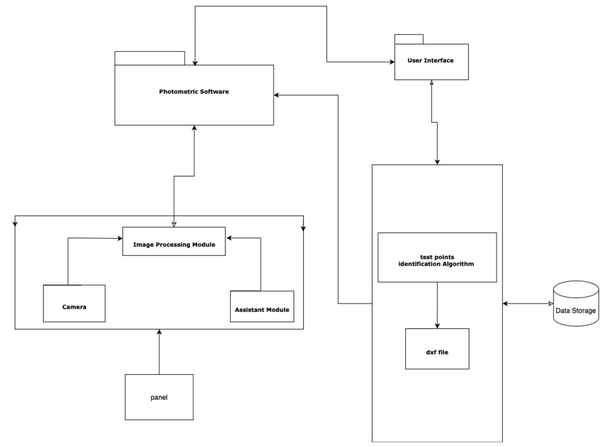
Future Work, References, and Acknowledgments

- Expand database for more DXF fonts
- Redefine OCR algorithm for better accuracy
- Scale to curved Lightplates and Lightplates of organic shapes.

References:
[1] "Quick-info," Quick-Info - ezdxf 1.2.0 documentation, https://ezdxf.readthedocs.io/en/stable/
[2] Mozman, "Mozman/ezdxf: Python interface to DXF," GitHub, https://github.com/mozman/ezdxf
[3] "Pyautocad," PyPI, https://pypi.org/project/pyautocad/ (accessed Mar. 10, 2024).

Workflow and Test Design

Thorough testing has been conducted using pre-collected Photometrica captures and their corresponding DXF files. The following flow chart provides a high-level description of how each part interacts with the other.



CSV File Standardization - Test Points Delivery

- Develop a sophisticated algorithm to extract and interpolate character data from DXF files, capturing test points accurately for further analysis. Account for the variability in font properties across different DXF files by incorporating a structured JSON database.
- Identify three key reference points for each character to track locations accurately and optimize data processing capabilities. Format all extracted data, including character symbols and their calculated central and reference coordinates, into CSV files to facilitate subsequent character recognition and data analysis.
- Format the CSV files according to the requirements of the Photometrica software system. Ensure that the file structure aligns with the software's specifications for seamless integration and optimal performance. Deliver the CSV files to the Photometrica software, enabling efficient data processing and analysis within the platform.

XY	1	ellipse	0.6598406305743083	2.205083360871285	0.1	0.1	0
XY	2	ellipse	0.7004454489394902	2.11527245594246	0.1	0.1	0
XY	3	ellipse	0.7922023301530317	2.100499076787102	0.1	0.1	0
XY	4	ellipse	0.7438600889456666	2.204092991437889 3	0.1	0.1	0
XY	5	ellipse	0.8416158214381539	2.204092991437889 3	0.1	0.1	0
XY	6	ellipse	0.9373268073447889	2.100498099422523 5	0.1	0.1	0
XY	7	ellipse	0.8900669172523976	2.205180776126013 6	0.1	0.1	0
XY	8	ellipse	0.9858660919603608	2.205180776126013 6	0.1	0.1	0

Results

Photometrica Report: Upon running all the required scripts ending with the data collection script over all the AOIs, the program will print a detailed report, listing the lighting characteristics of the Lightplate. This is achieved using built in report APIs in the Photometrica scripting language. The report will be formatted as a table with columns of all the AOI's, with the luminance, x chromaticity and y chromaticity values. The report includes the pass/fail conditions of these lighting characteristics. The placement of the AOIs as dots will also be shown on the PMM capture.

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