Measurement Project Proposal

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Method Description:

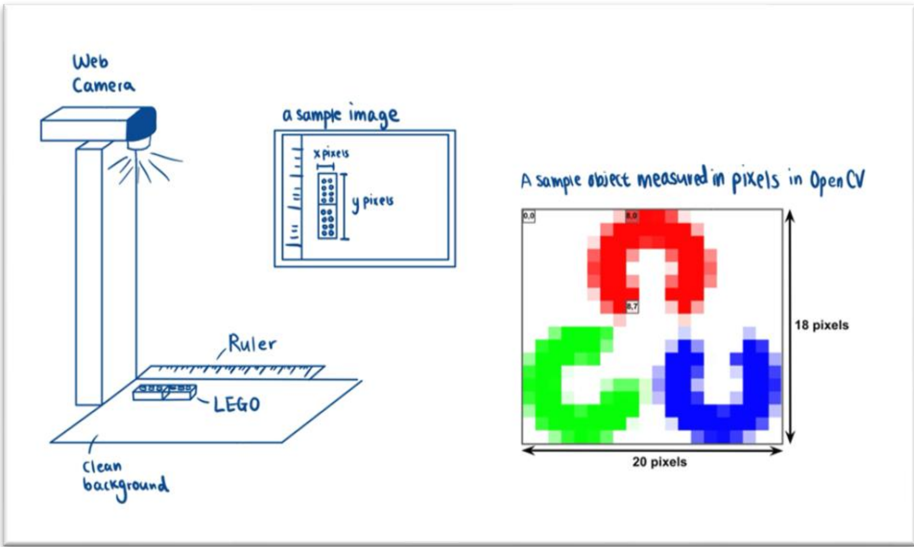
Our group will design a vision-based measurement system that determines the length and width of Lego blocks using a web camera and manual pixel-to-millimeter calibration. A fixed, top-down camera will capture an image of the Lego brick placed beside a metal ruler on a flat surface. By identifying the pixel coordinates of the Lego's edges and comparing them to ruler markings of known spacing, we will convert pixel distances into physical lengths using a manually derived calibration equation.

At its core, the system relies on the first principle that a digital camera (optic sensor) consists of a grid of pixels, each corresponding to a small, fixed area on the image plane. When light passes through the lens, points on the object project onto specific pixels. Therefore, the number of pixels between two edges on the image is proportional to the actual distance between those edges in the real world.

To find the edges, we will use intensity-gradient edge detection in Python (OpenCV). The boundary between the Lego and the background produces a sharp change in brightness. The program will scan each row of pixels and locate where brightness changes most rapidly—the points of maximum gradient. These positions define the Lego's left and right (or top and bottom) boundaries in pixels. The pixel distance between these two edges will then be converted to millimeters using our calibration curve.

The camera will be mounted approximately 30 cm above the surface and aligned perpendicular (≈ 90°) to minimize perspective distortion and maintain a linear pixel scale. At this height, the camera's 1920 × 1080 image captures an area of roughly 160 × 90 mm, providing sufficient resolution for one to three Lego bricks while keeping the image sharp and distortion low.

Setup Sketch:



Secondary Standard:

A ruler will serve as the secondary standard. We will photograph several known ruler spans (10 mm – 120 mm) and measure their pixel separations (Δpx). These pairs will be plotted to create a calibration curve relating true length (Ltrue) to pixel distance:

$$L_{\text{true}} = a(\Delta\text{pixels}) + b$$

The slope a represents the pixel-to-millimeter conversion factor. The equation will be obtained through plotting and fitting a trendline.

Expected Resolution:

With a 160 mm field of view across 1920 pixels (when placing the camera at about 30 cm height), the image scale is approximately

$$0.083 \text{ mm/px}.$$

Edge positions can be refined to roughly 0.1-pixel accuracy by interpolating brightness gradients, however, real world effects also must be accounted—lighting variation, lens distortion, and focus drift—and thus the practical resolution is expected to be 0.10 – 0.20 mm, which will be confirmed through error analysis and repeat measurements.