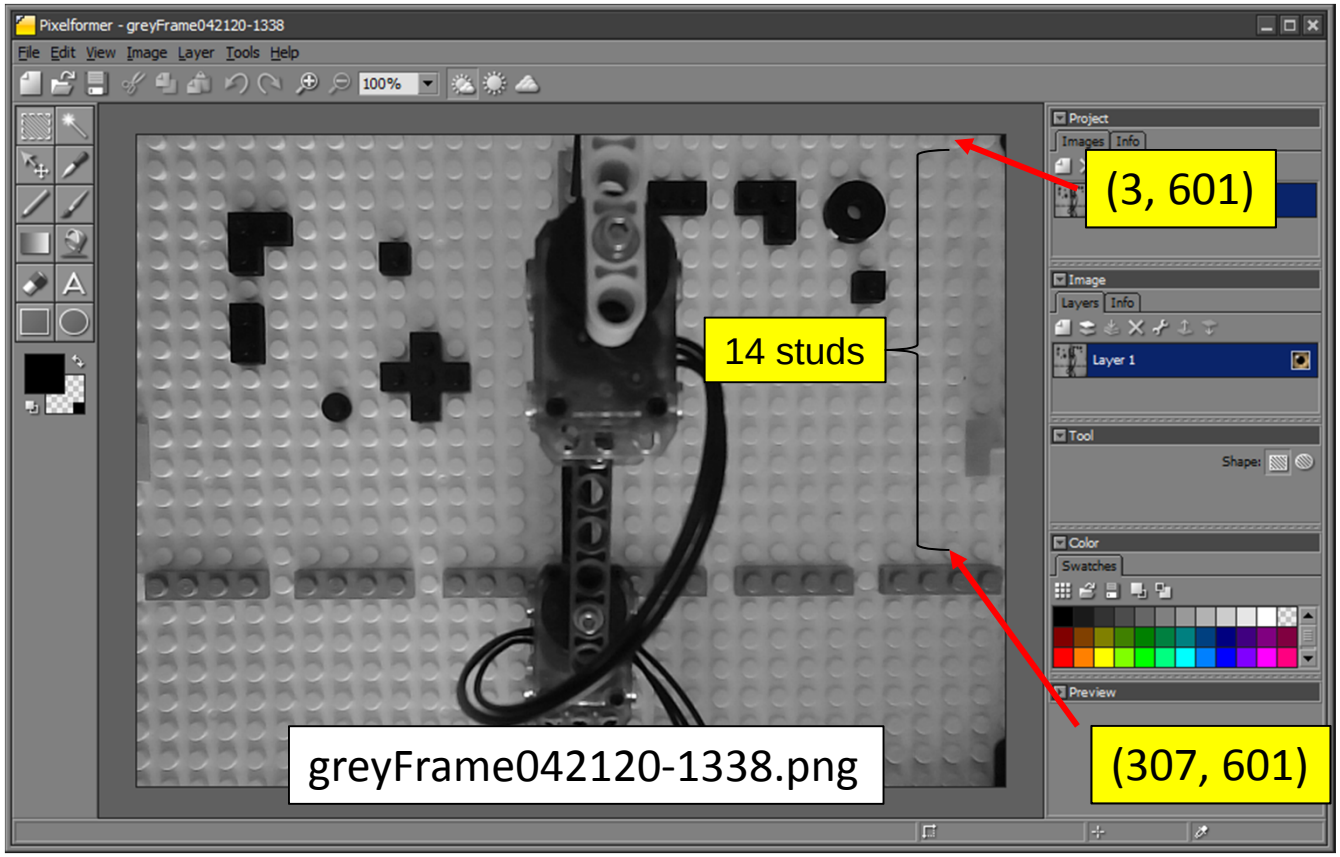
Objective: Calculate camera's lens focal length



Sample grey-scale image captured from Scilab as a PNG file and imported into Pixelformer.

Black Lego 1x1 round studs are on the top left and right corners…

However, the camera's FOV misses the top-left one and gets about half of the top-right one.

Baseplate studs are clear and can be counted for calibration purposes.

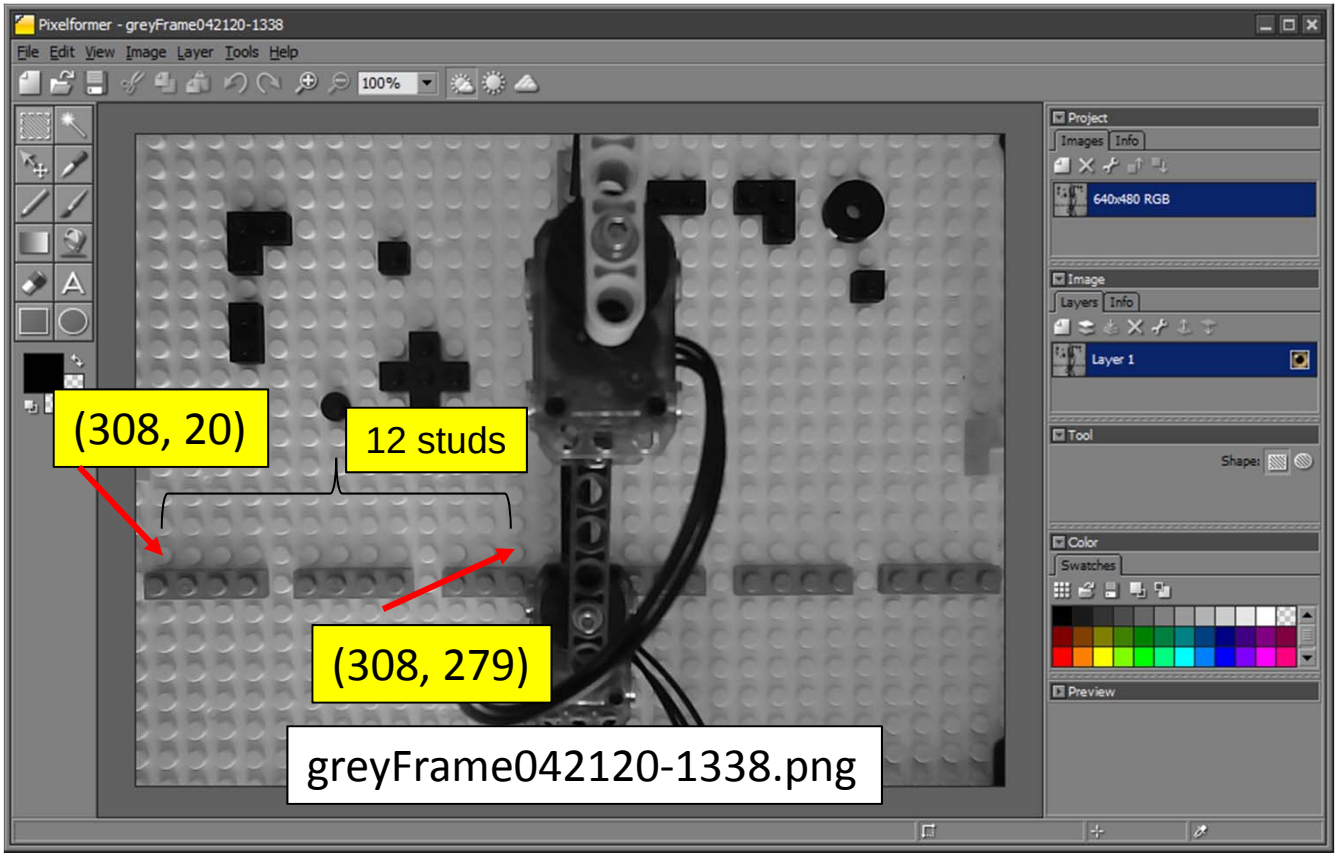
Also note that lens distorts image a bit and baseplate is not fully aligned with lens imaging sensor

Recall, 17 Bricks between base plate and camera's lens. Each Brick measures $6\ \text{mm}$ high. Thus $z = 17 \times 6\ \text{mm} + 1\ \text{mm}\ (\text{due to last stud}) = 103\ \text{mm}$

A ruler measures the height (black brace) to be 11.3 cm. Alternatively, one counts 14 stud spacings hence $H = 14 \times 8\ \text{mm} = 112\ \text{mm} = 11.2\ \text{cm}$ which is close to ruler measurement

Answer: Hence $f = z\frac{h}{H} = 103\ \text{mm}\frac{303\ \text{pixels}}{112\ \text{mm}} = 278.65\ \text{pixels}$

Ref: focalLengthCalculations-042220



Recall, 17 Bricks between base plate and camera's lens. Each Brick measures 6 mm high. Thus $z = 17 \times 6 \text{ mm} + 1 \text{ mm (due to last stud)} = 103 \text{ mm}$

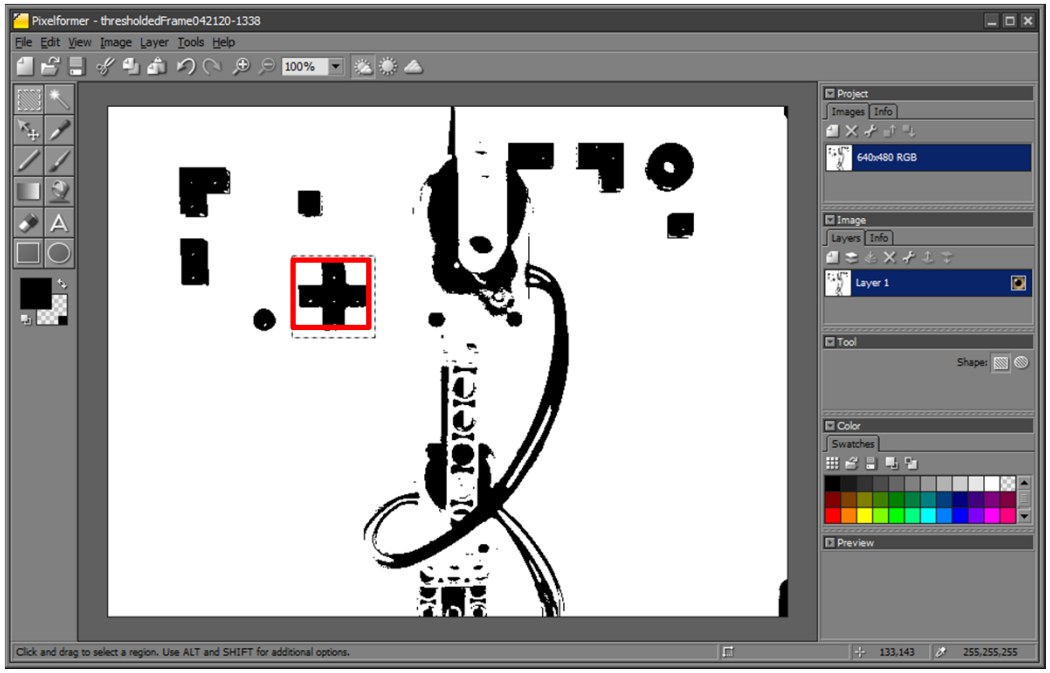
A ruler measures the height (black brace) to be 9.5 cm. Alternatively, one counts 12 stud spacings hence $H = 12 \times 8 \text{ mm} = 96 \text{ mm} = 9.5 \text{ cm}$ which is close to ruler measurement

Answer: Hence $f = z\frac{h}{H} = 103 \text{ mm}\frac{(279-20) \text{ pixels}}{96 \text{ mm}} = \mathbf{277.89 \text{ pixels}}$

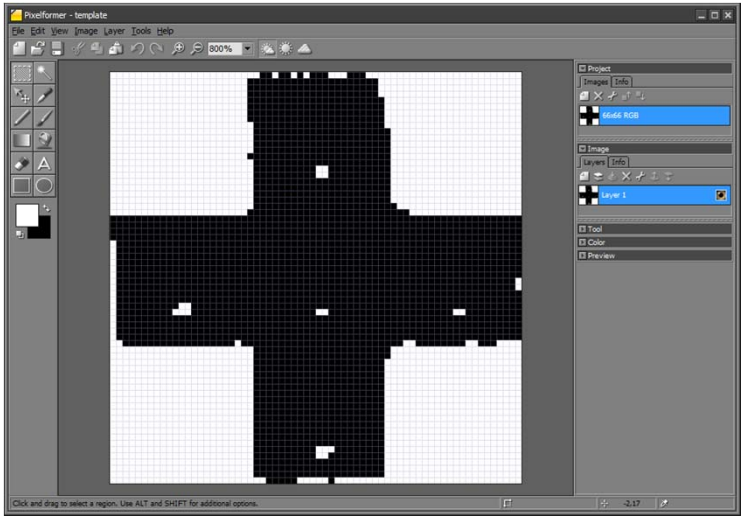
NB: this f value is close to the previous one (278.65). So, can just round both to 278 or use the first one for rows and second for columns

Ref: focalLengthCalculations-042220

Objective: Map image space (pixels) to robot's task space



640 x 480: **thresholdedFrame.png**



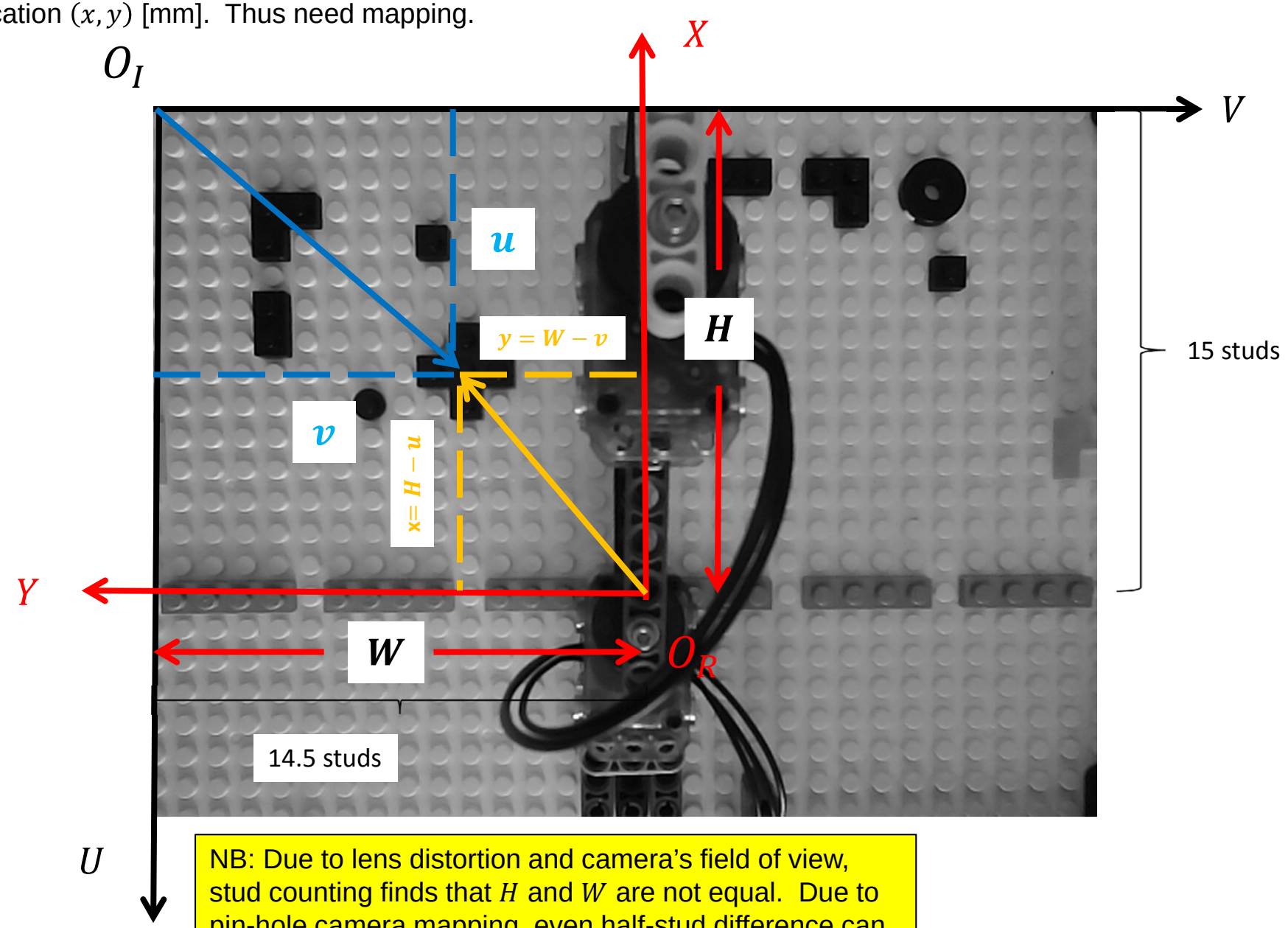
66 rows x 66 cols i.e. (66, 66)
template.png

Thresholded PNG file from Scilab imported into Pixelformer (left). Target cropped (red box) to yield a template (right) that's exported as a PNG file.

NB1: Crop to Cross' perimeter and avoid surrounding white pixels
NB2: Template doesn't have to be perfectly square – this case just happened to yield one

Ref: focalLengthCalculations-042220

Image frame origin O_I yields target center location (u, v) [pix]. Robot's frame origin O_R yields target center location (x, y) [mm]. Thus need mapping.



NB: Due to lens distortion and camera's field of view, stud counting finds that H and W are not equal. Due to pin-hole camera mapping, even half-stud difference can yield 5-10 mm error

Ref: focalLengthCalculations-042220

Mapping calculations for (+X, -Y) quadrant