ESTIMATION OF TERRAIN SHAPE USING A MONOCULAR VISION-BASED SYSTEM

Mid-Project Demonstration

Connor Luke Goddard (clg11)

March 16, 2015

Aberystwyth University

Project Focus

Investigation into a system capable of utilising a single, forward facing colour camera to provide an estimation into the “shape” of the environment terrain.

Potential Areas of Investigation

- Detection of positive and negative obstacles.
- Detection of non-flat terrain (i.e. slopes).
- Estimation of the current speed.
- Estimation of the current rotation angle.

Approach focussed on the effects of **motion parallax**.

i.e. Objects/features that are at a greater distance from the camera appear to move less from frame-to-frame than those that are closer.

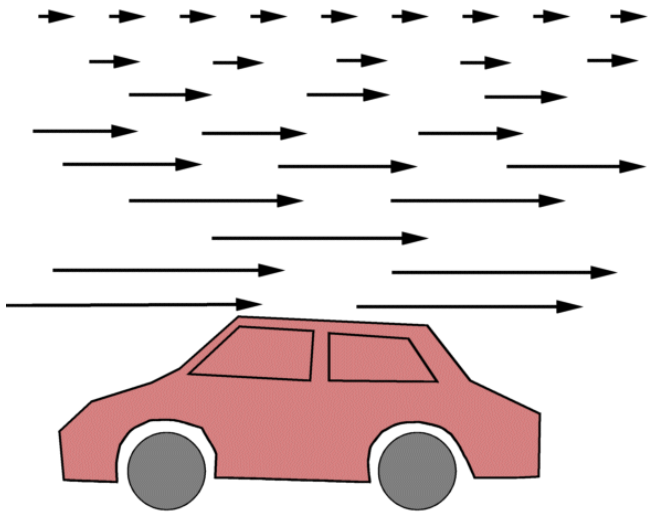


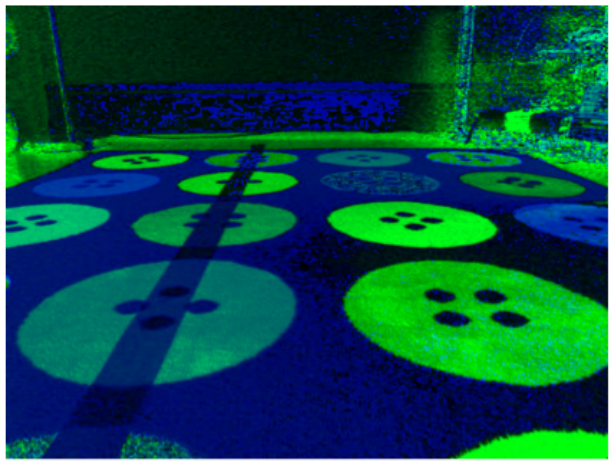
Figure 1: Typical example of motion parallax. **Courtesy**: http://www.infovis.net.

Stage One

Import two consecutive images, and convert from RGB (BGR in OpenCV) colour space to HSV.

RGB (BGR) Colour Space

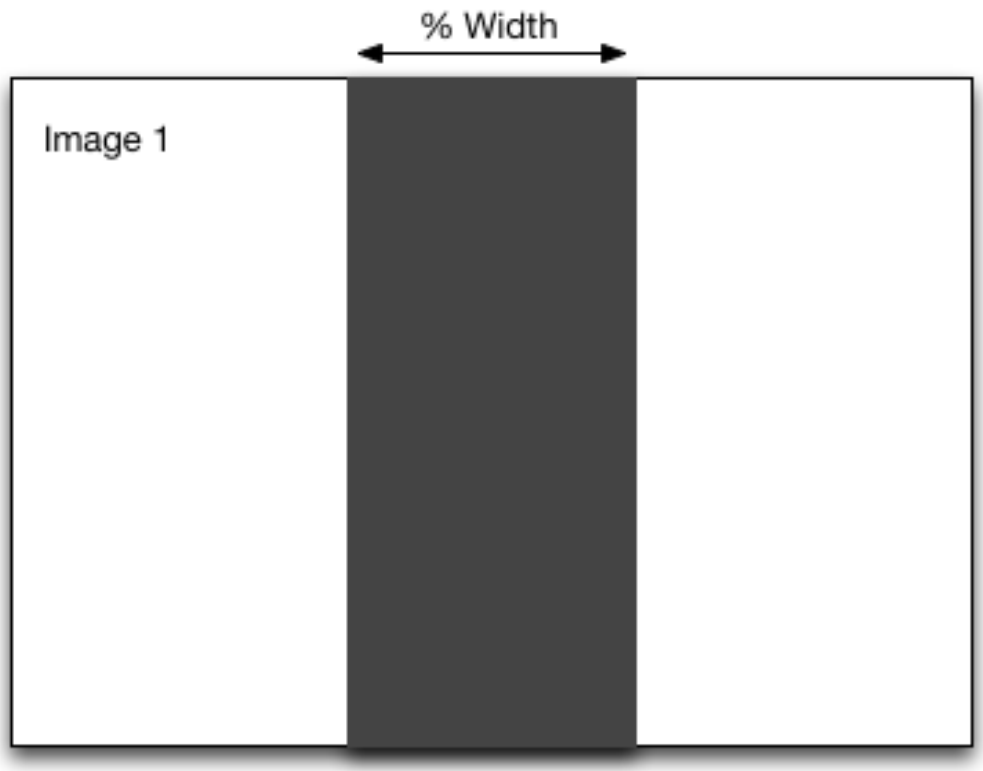
HSV Colour Space (Luminance (V) Removed)



The 'V' channel is then removed in order to improve robustness to lighting changes between frames.

Stage Two

Extract a percentage-width region of interest (ROI) from centre of first image.



Why do we need to extract a ROI?

Focus-of-expansion: Objects in images do not actually move in 1-dimension (i.e. straight down the image).

This effect is minimised towards the centre of the image.

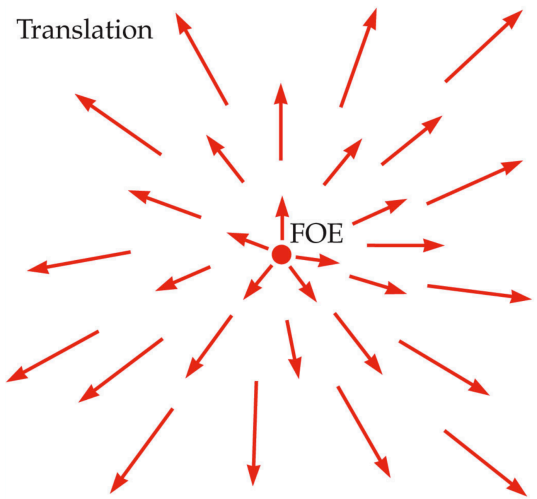


Figure 2: **Courtesy:** J.Pillow, University of Texas

Stage Three

Extract patches of a fixed size around each pixel within the extracted ROI.

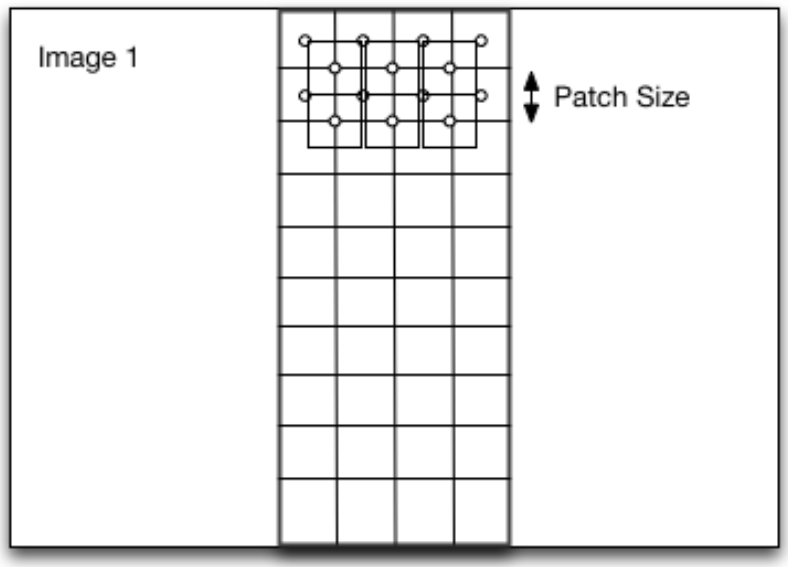


Figure 3: **Simplified** example of patch extraction within ROI.

Stage Four

For each patch extracted from *image one*, move down through a localised search window (column) in *image two* searching for the best match against the template patch.

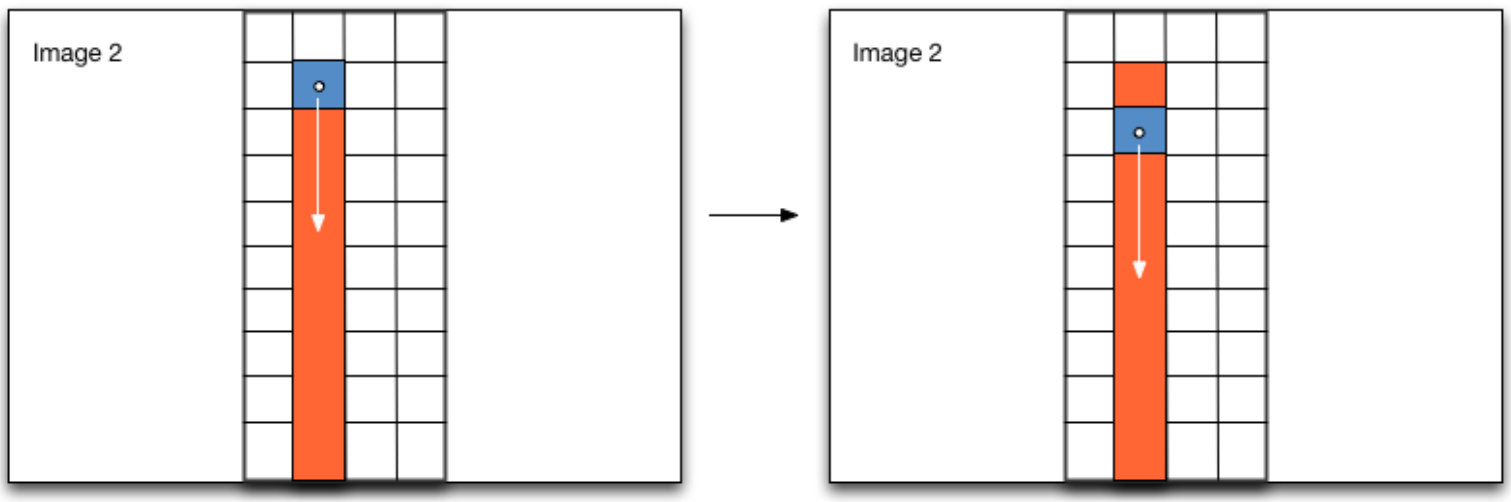
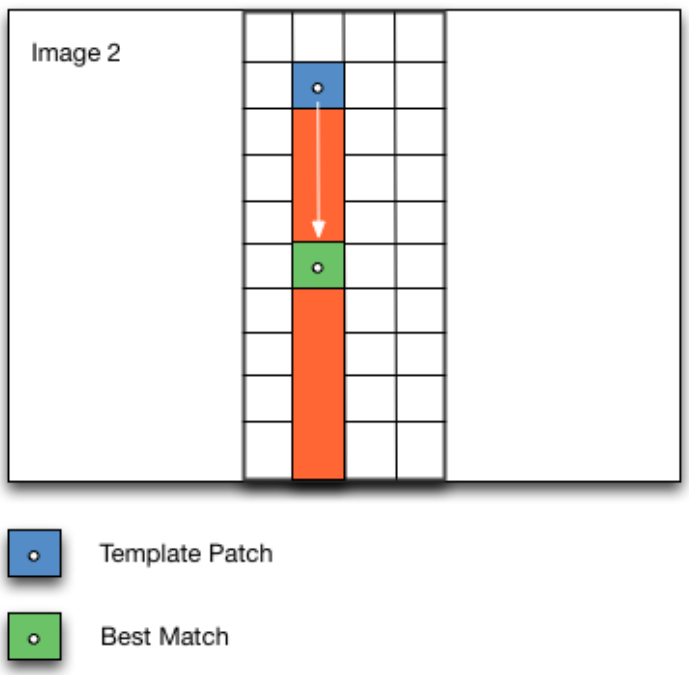


Figure 4: Example of “best match” search within local column.

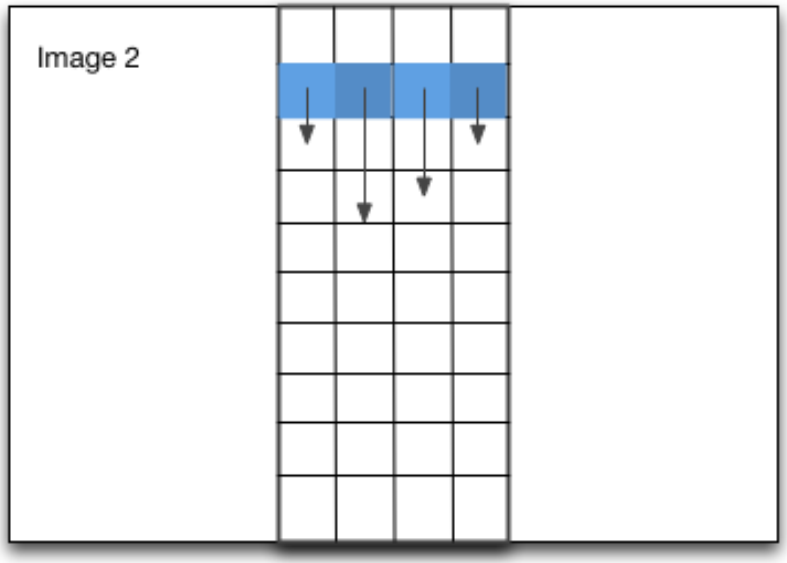
Stage Five

Identify the patch within the localised search window that provides the “best match” via correlation-based matching (e.g. Euclidean Distance, SSD or Correlation coefficient).



Stage Six

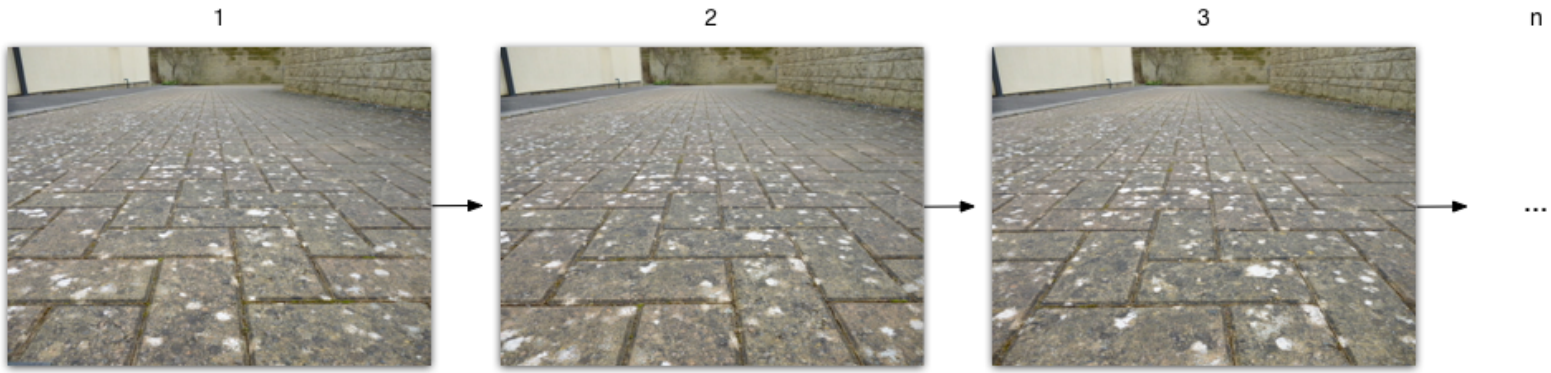
Average all measured displacements for each pixel along a given row.



Outliers are removed by ignoring any displacements that lie outside of (2 x Standard Deviation) of the mean.

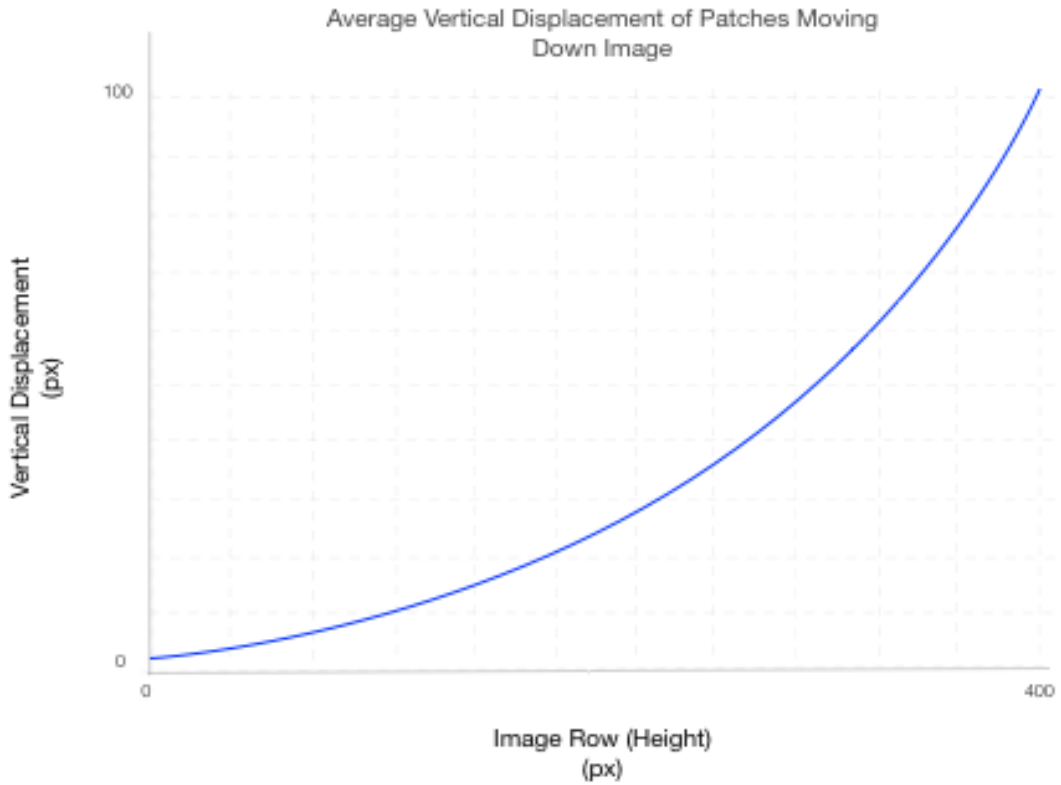
Repeat Stages 1-6

Repeat stages 1-6 for an entire collection of “calibration” images taken of *flat, unobstructed* terrain.



Stage Seven

Plot the *average displacement* for each ROI row, calculated from the displacements recorded over all calibration images.



RESULTS

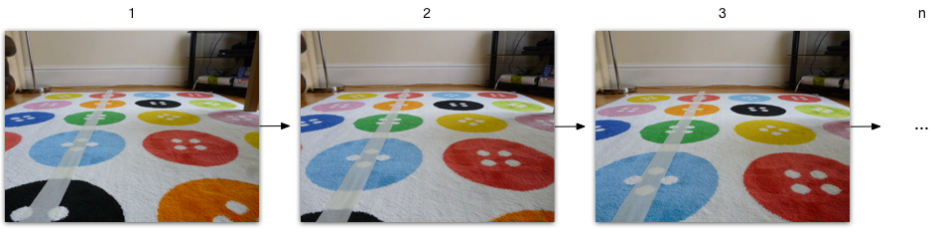
Generally “mixed” results at this stage.

From the results obtained, we have learned:

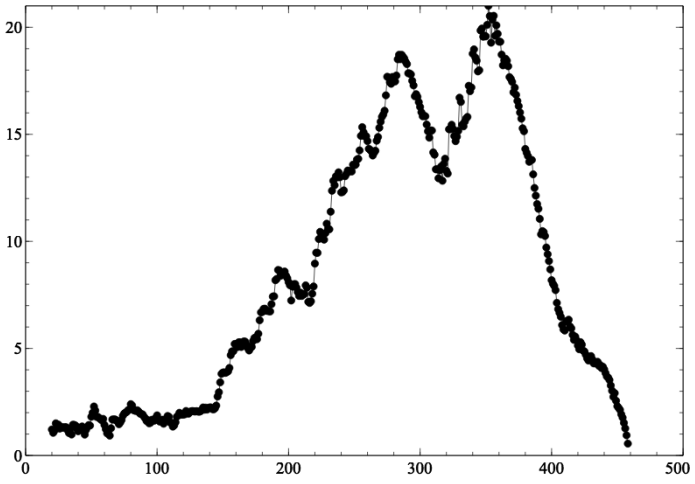
1. It is possible to potentially establish a relationship between row height in an image, and average downwards pixel displacement.
2. The current approach to appearance-based tracking using multiple “small” patches **does not work well** for many typical terrain conditions (i.e. outside).

RESULTS: EXAMPLE 1

Input Collection:

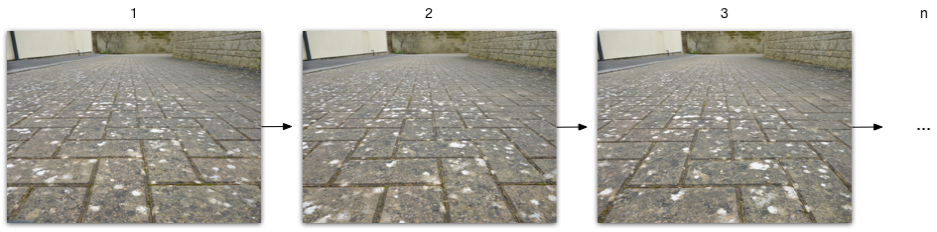


Result:

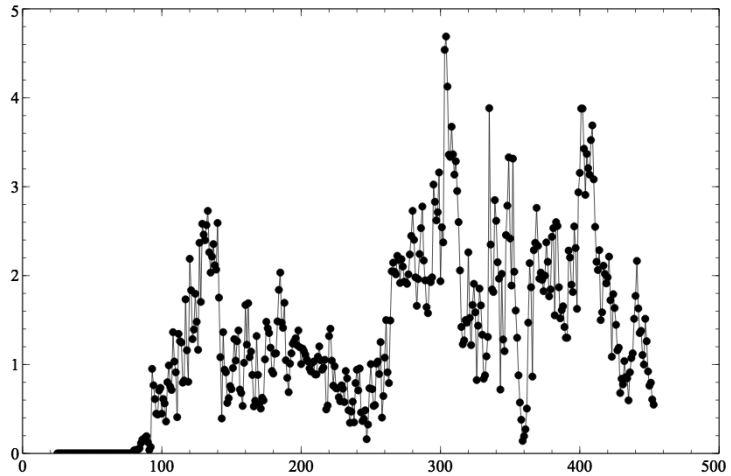


RESULTS: EXAMPLE 2

Input Collection:



Result:



PROJECT MANAGEMENT

Project is adopting a SCRUM-based approach to project management.

- **Releases** - Major feature sets (e.g. work up to mid-project demo)
- **Sprints** - Weekly time-boxed portion of work effort.
- **Sprint Review & Retrospectives** - Conducted as part of weekly project meeting with tutor.

Tools: *Github Issues* with *Waffle.io* (KANBAN), *Burndown.io* (Burndown charts).

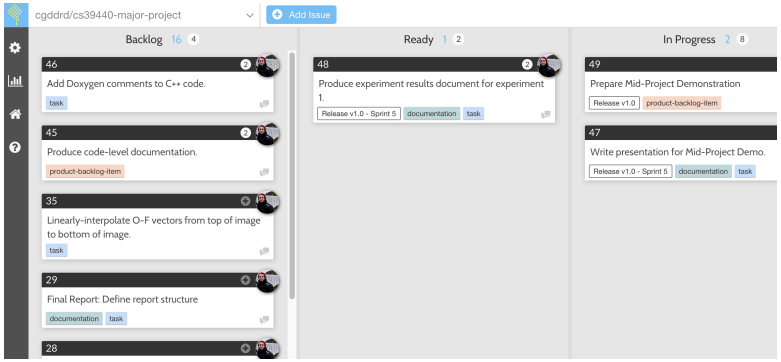


Figure 5: Waffle.io KANBAN board interface to Github Issues.

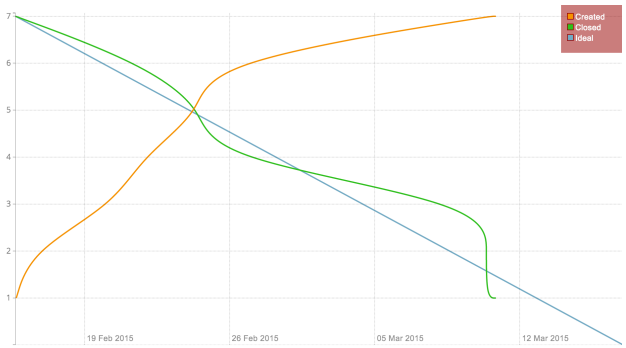
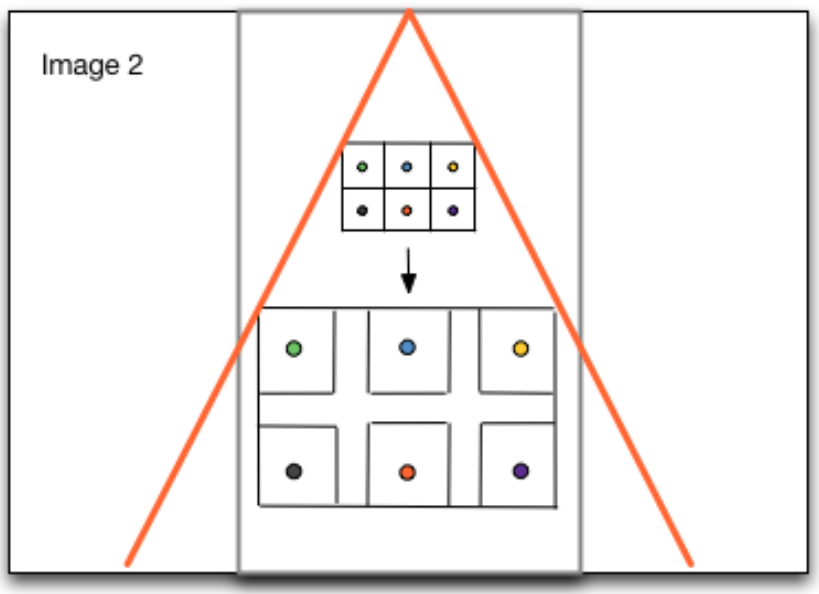


Figure 6: Burndown chart for Release v1.0. **Courtesy:** http://burndown.io

NEXT STEPS

Plan is to move away from multiple small patches instead adopting a single, larger patch to represent a single row.

Template patch will be scaled relative to its centre as the search moves down the image. This is to account for perspective distortion (**i.e.** objects becoming larger as they move closer to the camera).



Any Questions?

Project Blog

Slide Design: Matthias Vogelgesang - (Github)