3D PASSIVE STRUCTURED LIGHT FOR PLANETARY LANDERS

Spencer Newton

SPACE ROBOTICS

- Robots are sent to investigate environments on other planets instead of humans.

- Without humans present, a robot needs to be able to understand it's environment.
  - Discover Areas of interest
  - Path finding
  - Perform Scientific Tasks

- Stereo Vision is the most common technique
  - Robust and Reliable
  - Heavy (Costly), Bulky
  - Computationally Expensive
  - Requires lots of power

Curiosity 'Mastcam'

PASSIVE STRUCTURED LIGHT

- **Structured Light**
  - **Project pattern onto scene**
  - **Derive range information from deformation of pattern by terrain**
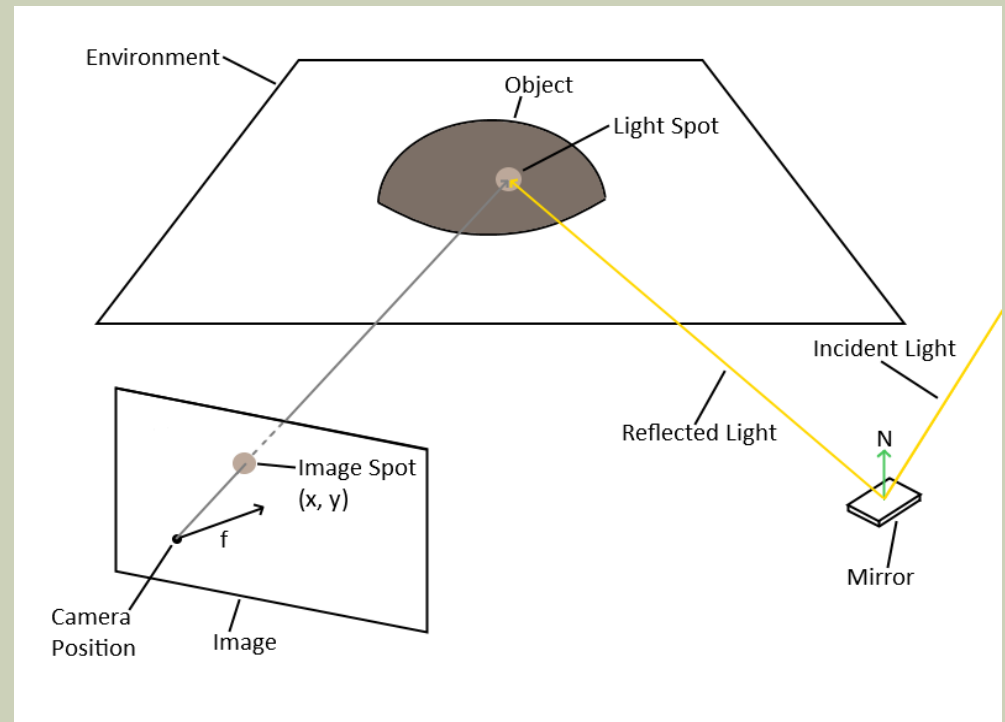
- **Passive Structured Light**
  - **Use reflected light to reflect spots of light onto terrain**

- **Advantages**
  - **One camera and Mirror**
  - **Less power, less weight**
  - **Spin-off use**

- **Disadvantages**
  - **Reliant on environment conditions**

PASSIVE STRUCTURED LIGHT

1. Light from the sun is incident on a mirror (of set of)

2. Reflected light causes a spot to appear in the environment

3. An image of the environment is taken with the camera

4. **The light spot should be found in the image**

5. Calculate reflected light vector and image light spot vector

6. Point of intersection of these two vectors is the 3D location of the spot in the world

7. Repeat to create cloud of 3D points representing environment

EXPERIMENT

- **Simplified version for experiment**

- **LED Torch as light source**
- **Grid paper on flat desk as environment**
- **Objects added in later on**
  - Black plastic charger
  - Multi-coloured cube
- **Multiple Mirrors Used**

- **Images taken of scene with light spots present in different 'environments'**
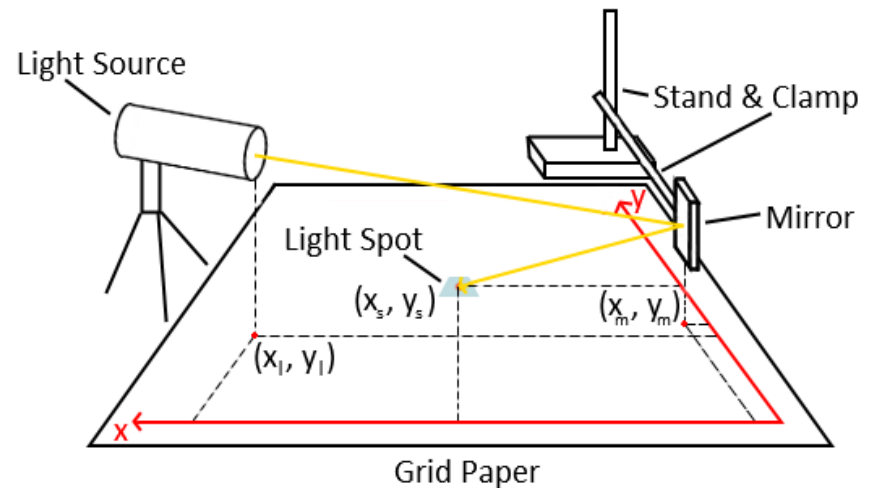
- **Images gathered from experiments were fed into light spot tracking program**

IMAGE PROCESSING

Colour Tracking

- Convert image to HSV colour space

- Threshold image based on minimum and maximum H/S/V parameters
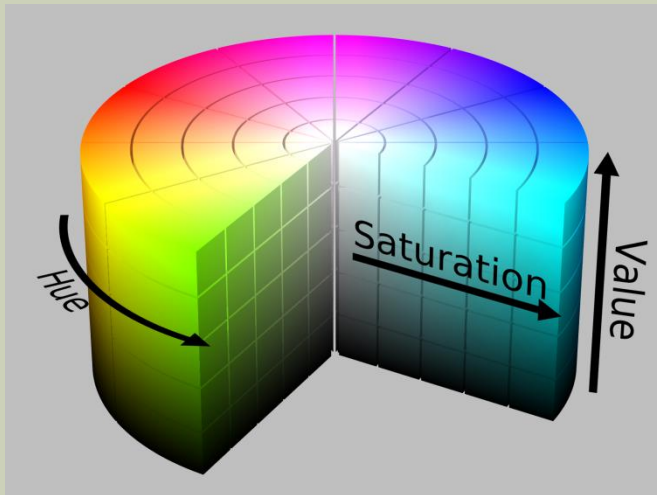
Difference Tracking

- Requires image of environment without light spot

- Convert both images to grey scale

- Calculate absolute difference for each pixel

- Threshold image based on sensitivity parameters

IMAGE PROCESSING
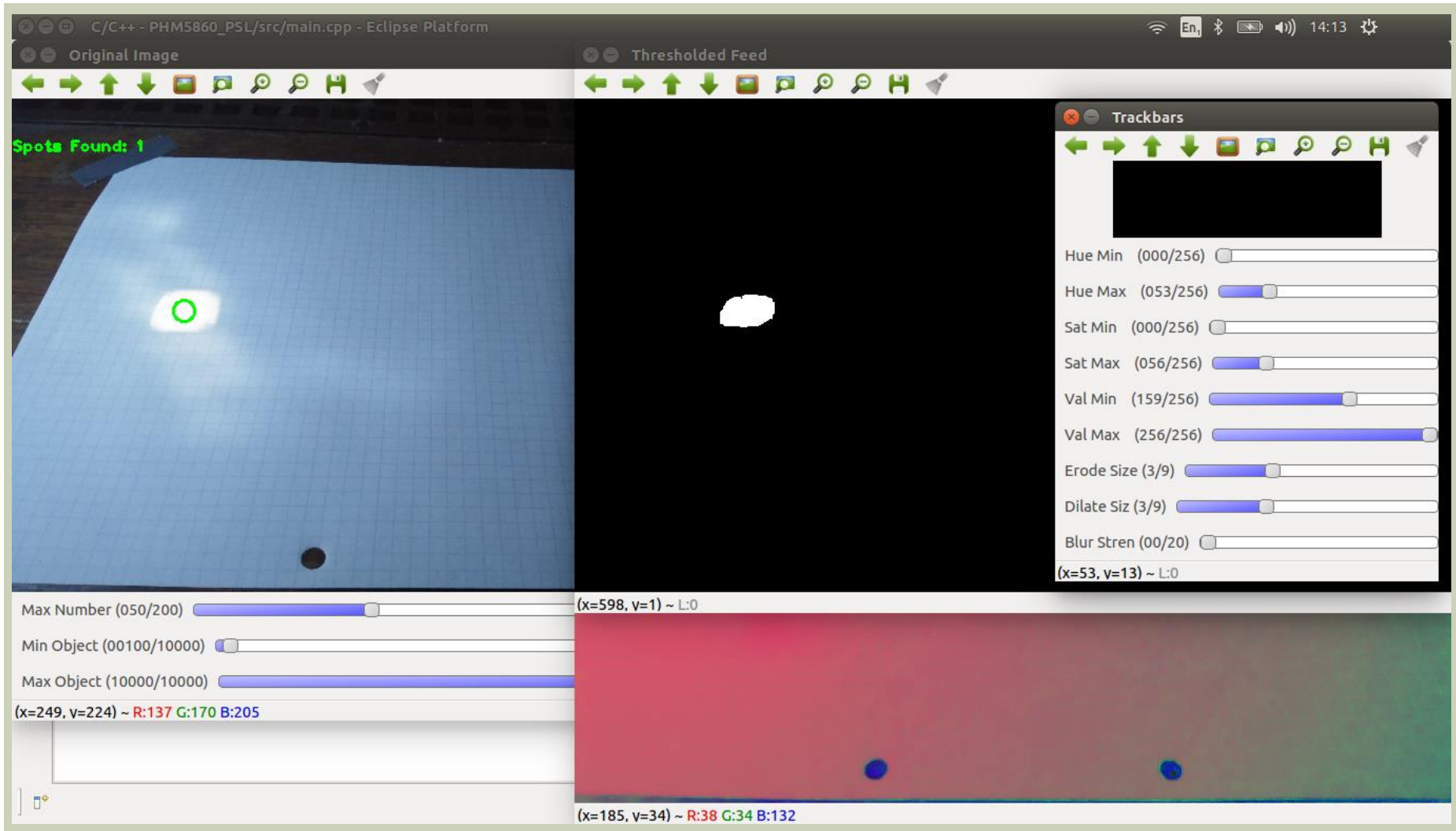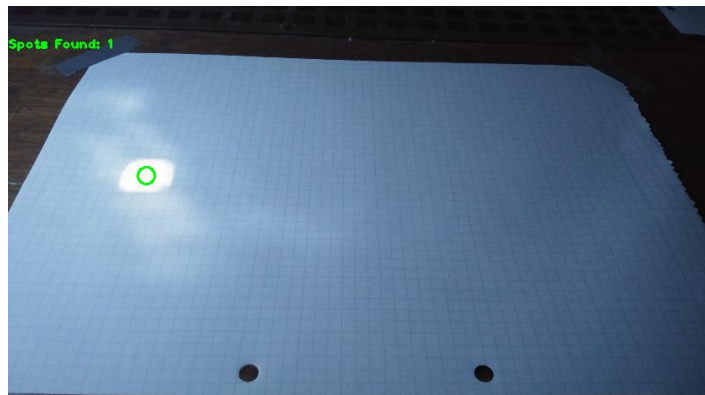
RESULTS

Single White Spot

HSV & Difference methods
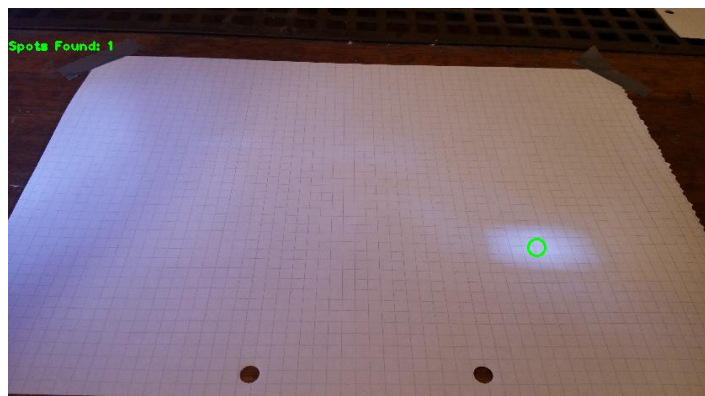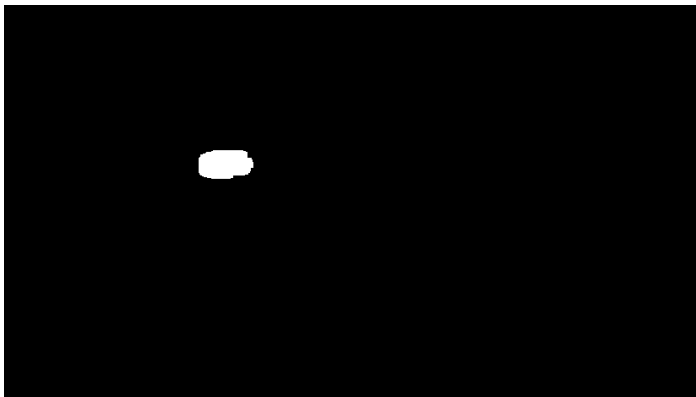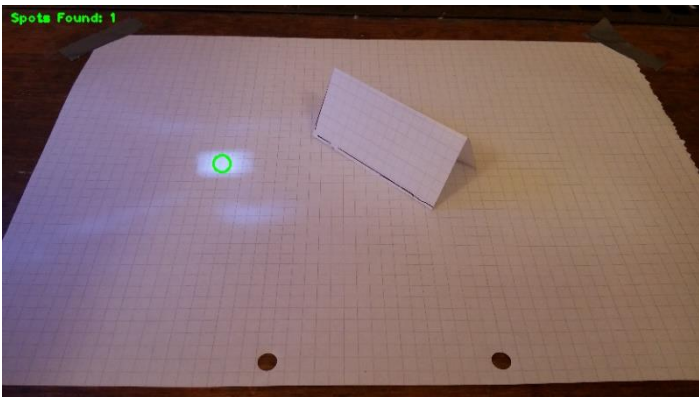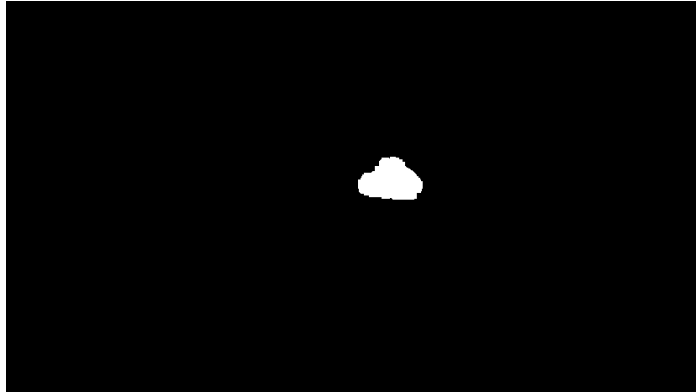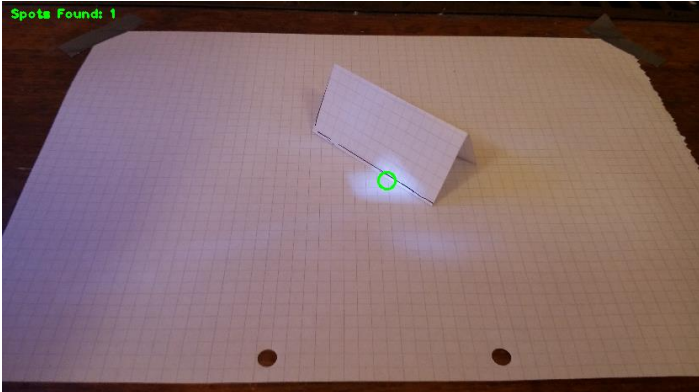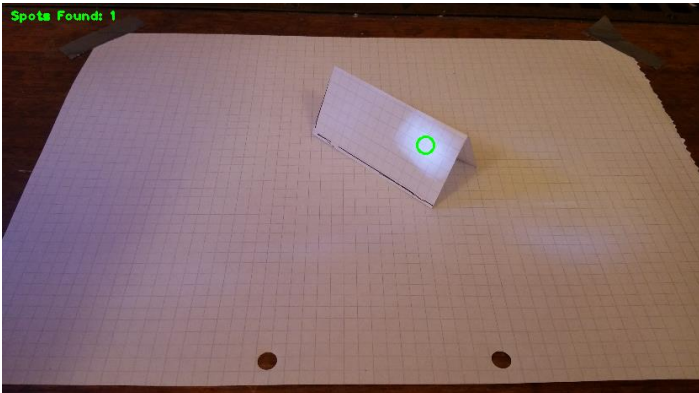
RESULTS

Single White Spot & paper obstacle

HSV & Difference methods
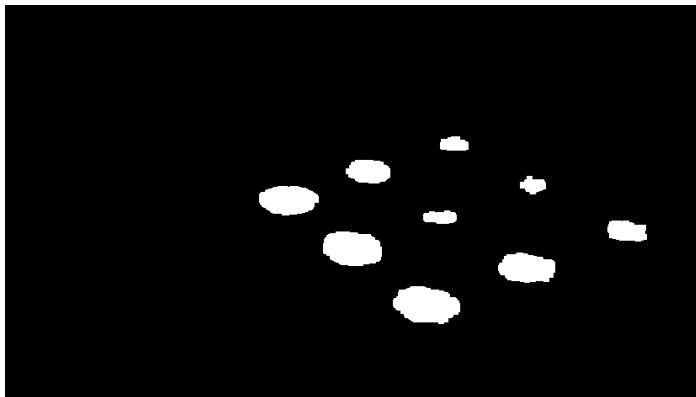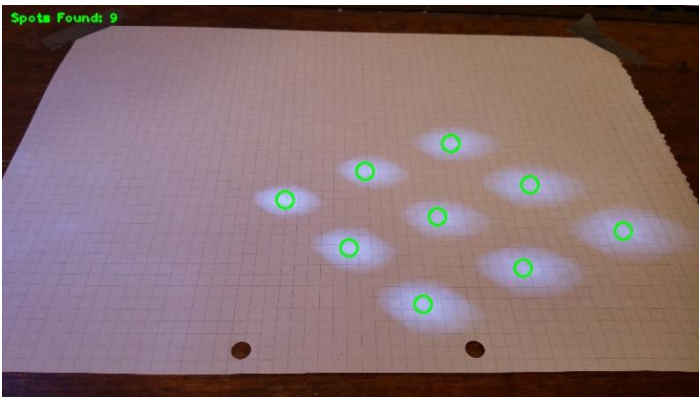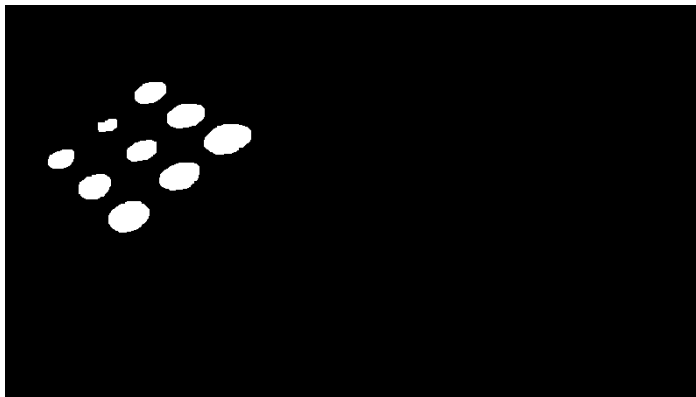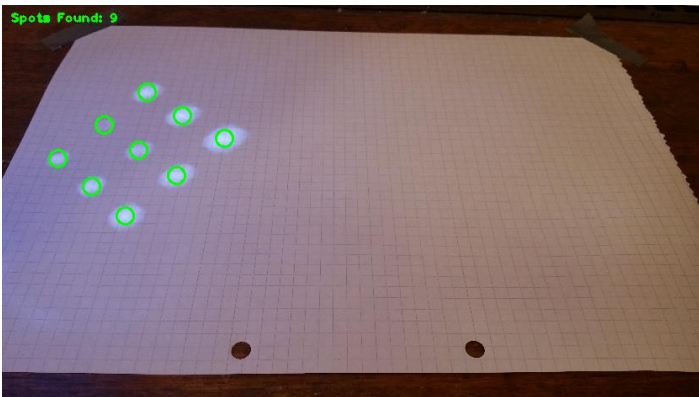
RESULTS

Multiple White Spots

HSV Method

- **Some dimmer than others**
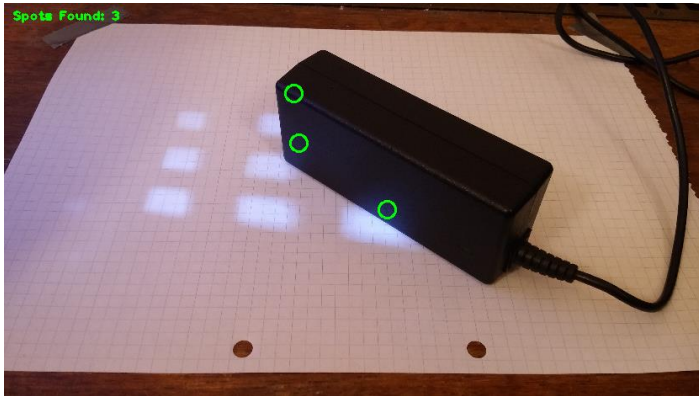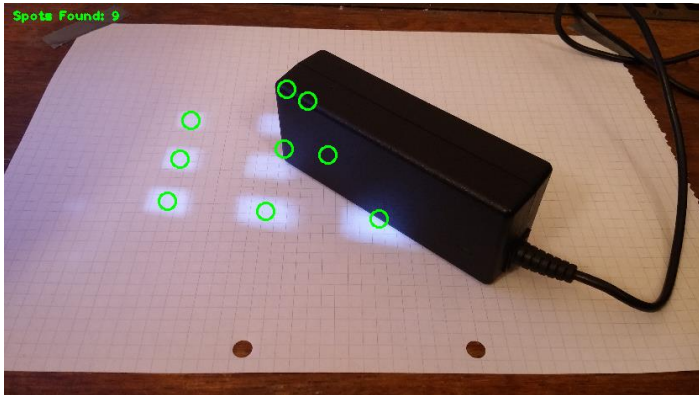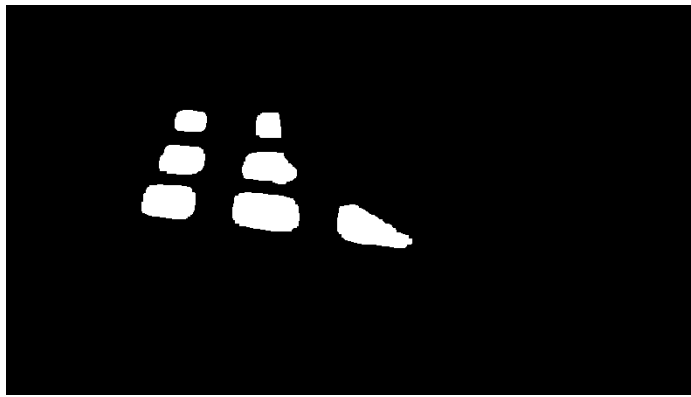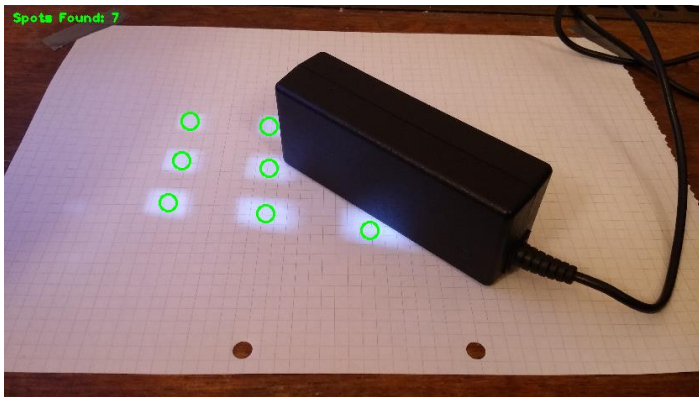- **Still performed well despite this**
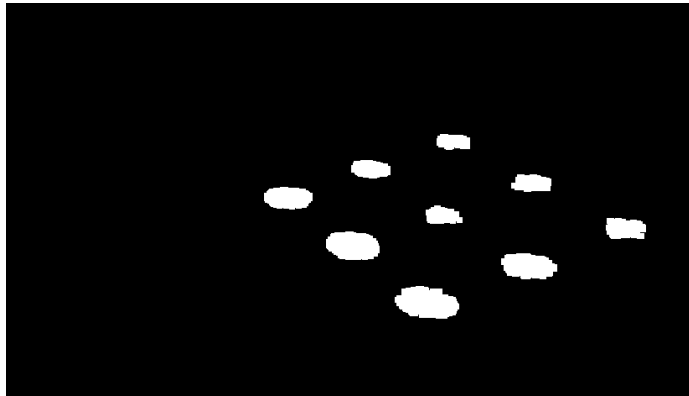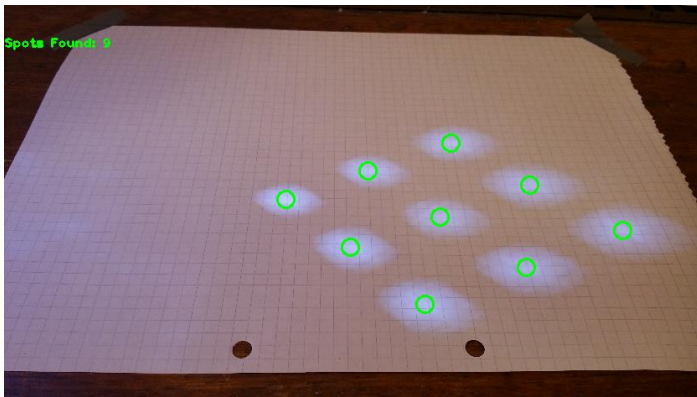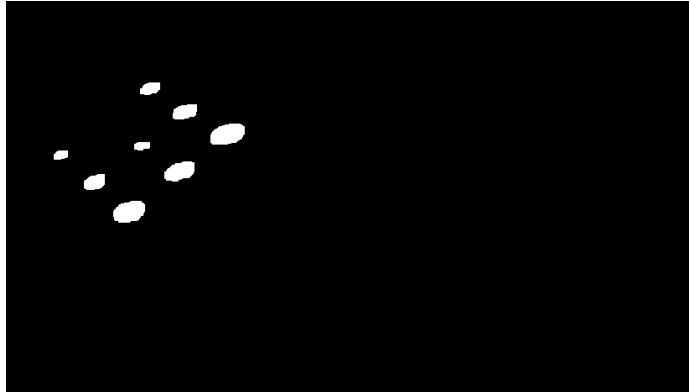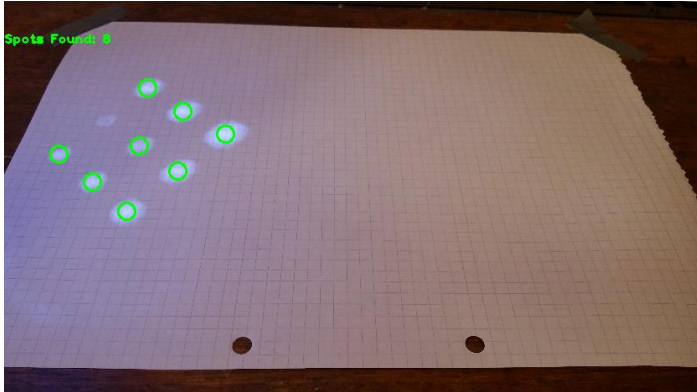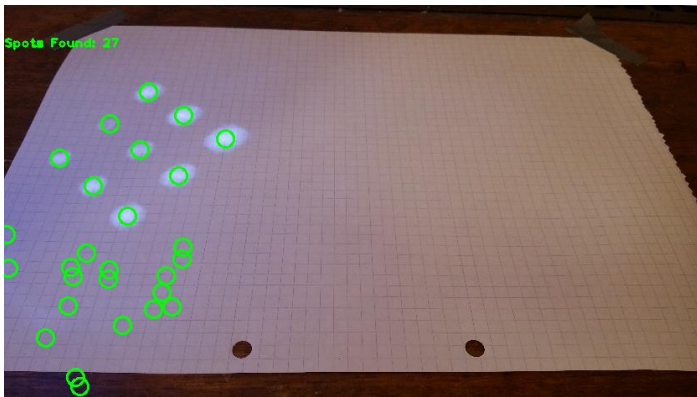
RESULTS

Multiple White Spots

Difference Method

- **Some dimmer than others**
- **Performed well in most cases**

- **Anomalous results (very dim spot)**

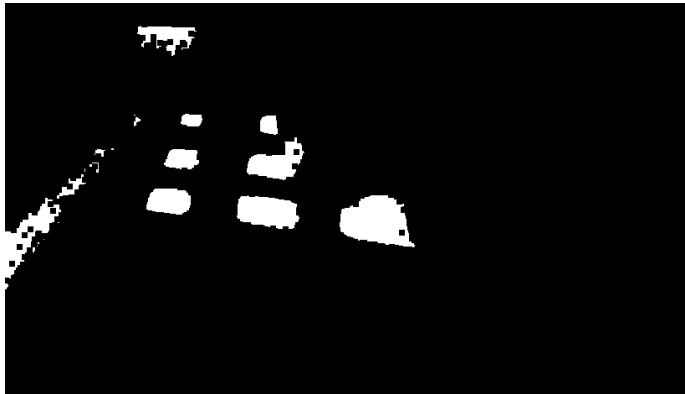- **Lowered sensitivity introduced too much background noise**
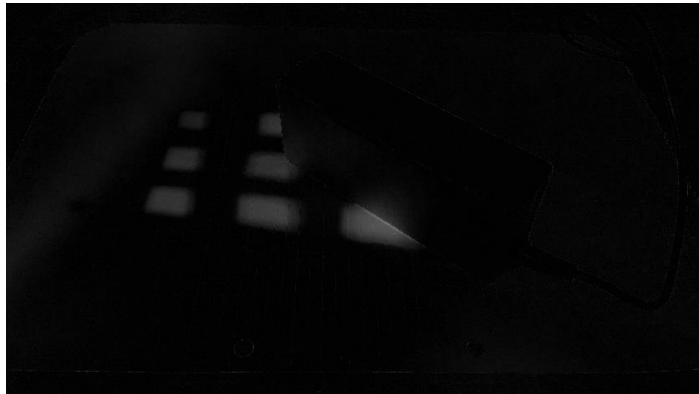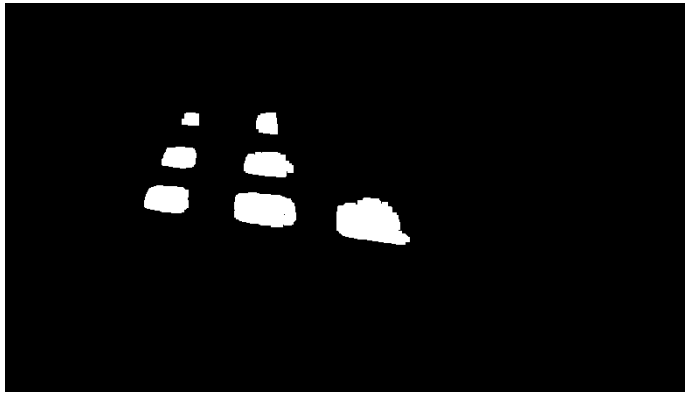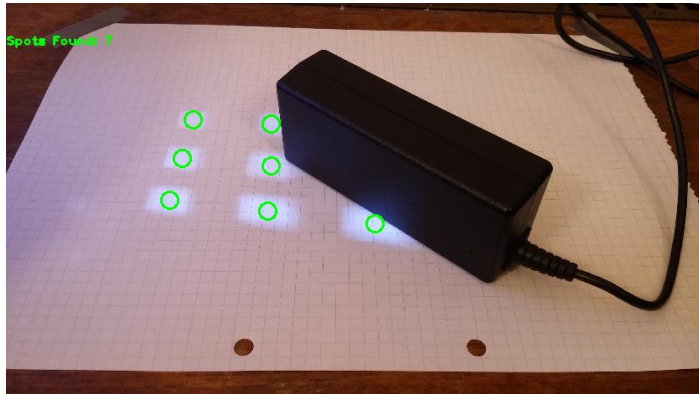
RESULTS

Multiple White Spots and black plastic object

HSV Method

- **Spot traceable on paper and object separately**

- **Attempt at finding on both at same time**

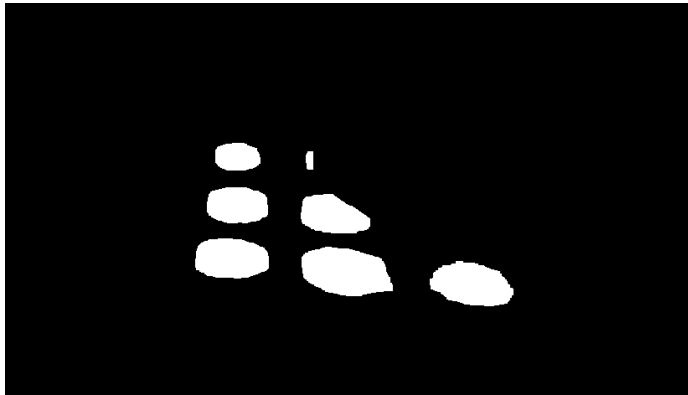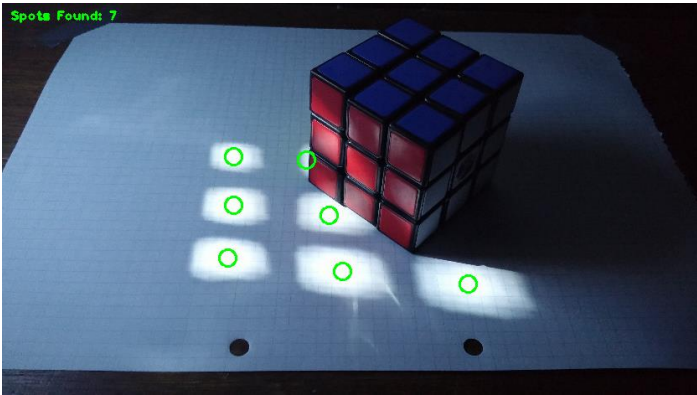- **Object surface properties changed light spot quality**
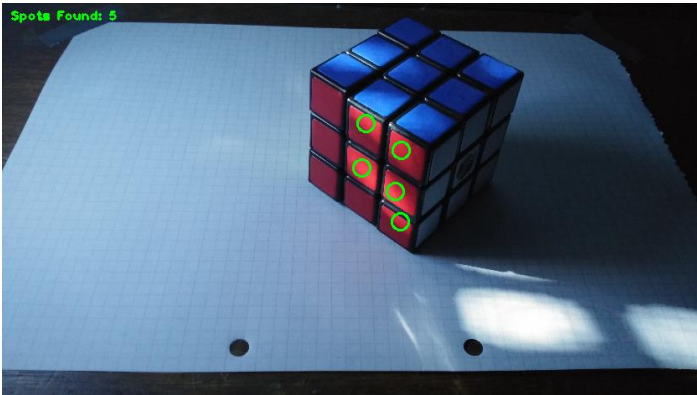
RESULTS

Multiple White Spots and black plastic object

Difference Method

- **Spots traceable on paper**

- **Causes small differences when incident on object**

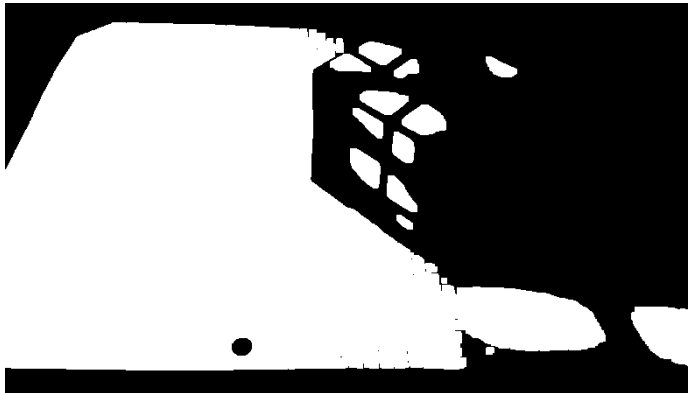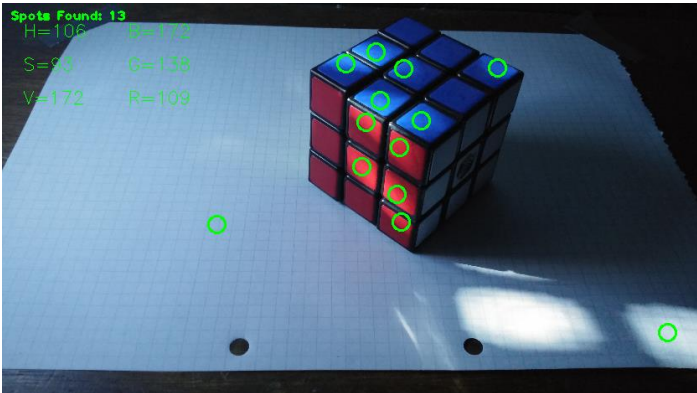- **Lowered sensitivity introduced too much background noise**
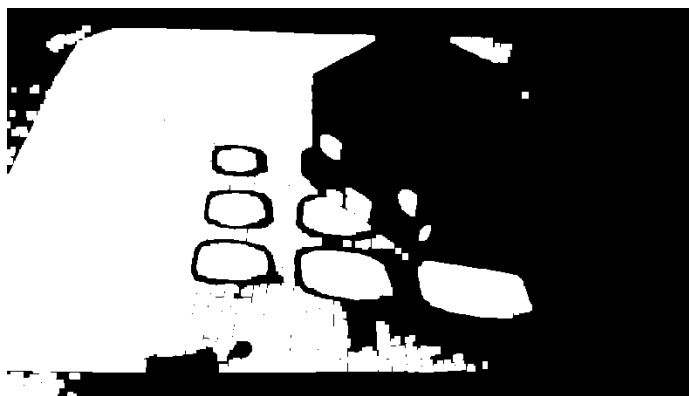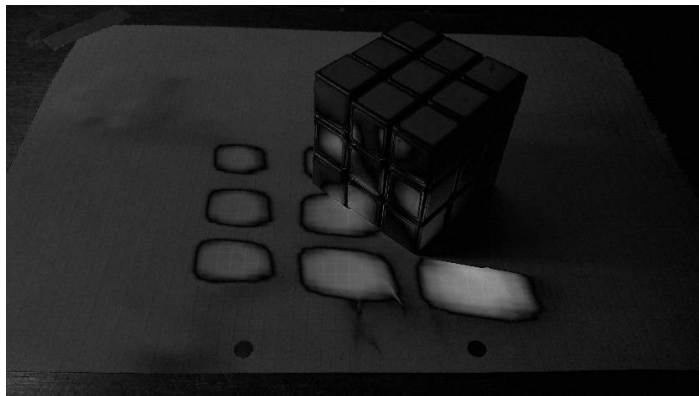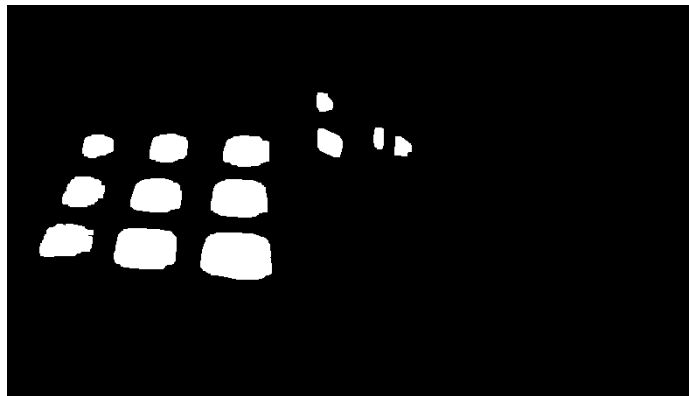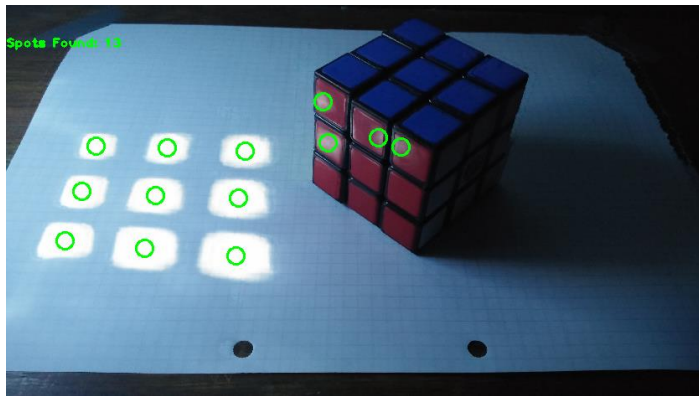
Multiple White Spots and a multi-coloured object

HSV Method

- **Spots traceable on paper**

- **Surface made light spots a different colour**

- **Untraceable on both sides without introducing too much background noise**
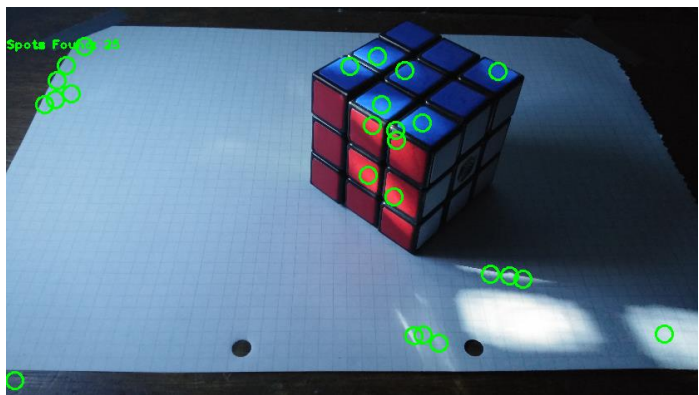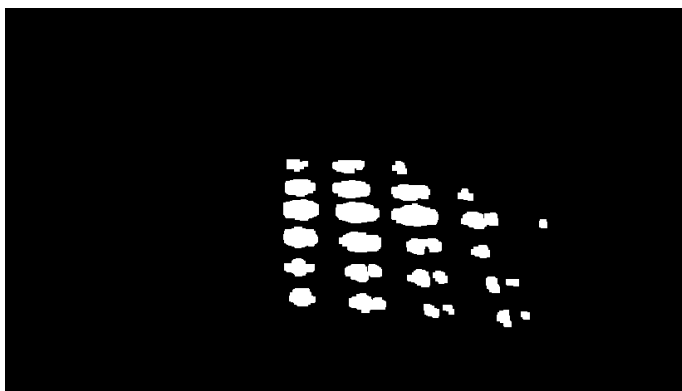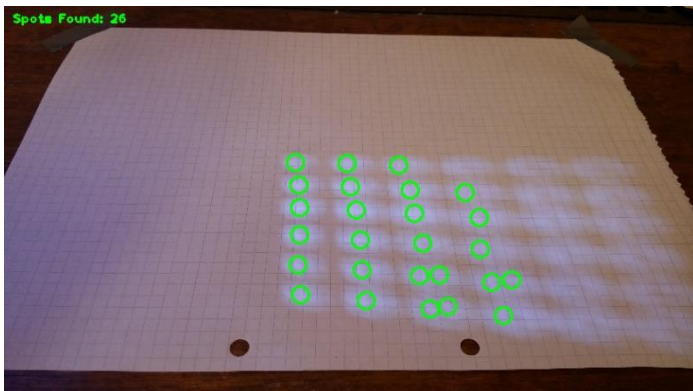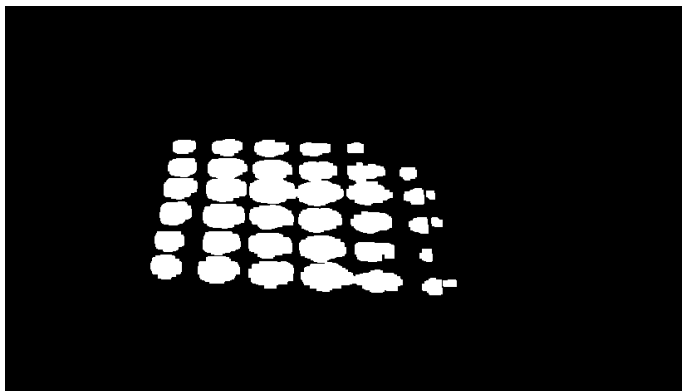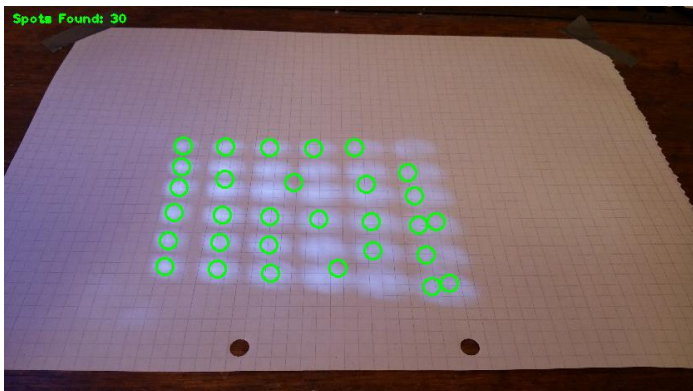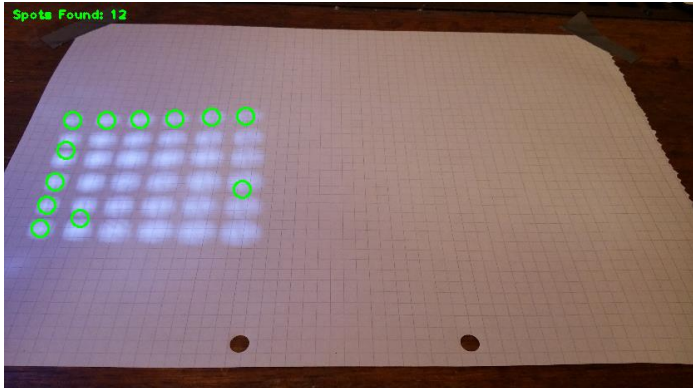
RESULTS

Multiple White Spots and a multi-coloured object

Difference method

- **Spots traceable on paper**

- **Specular reflections seen as spots**

- **Base image taken poorly**

- **Surface colour is insignificant**

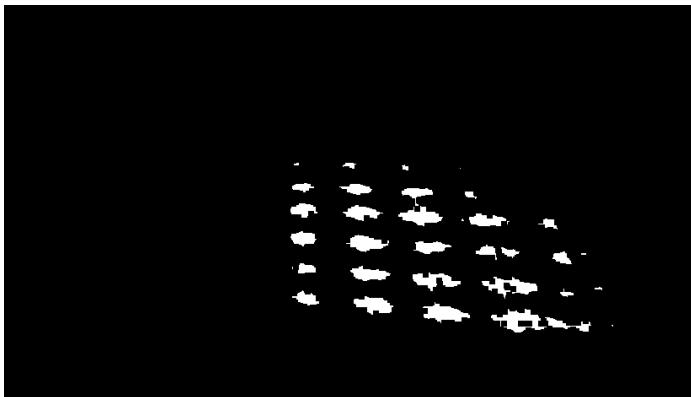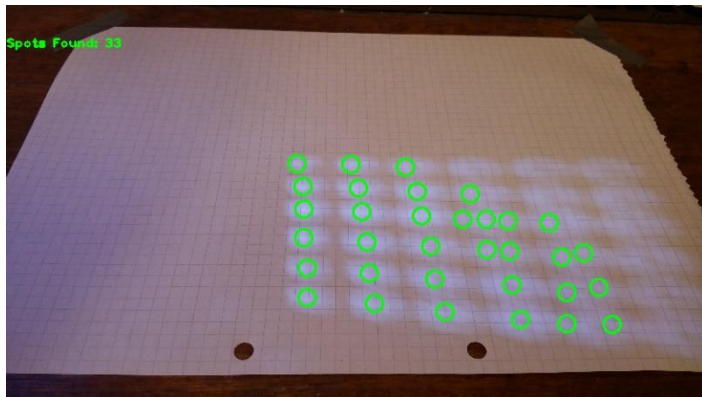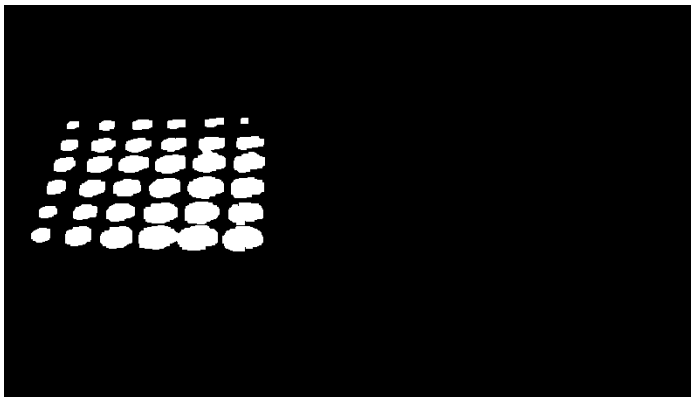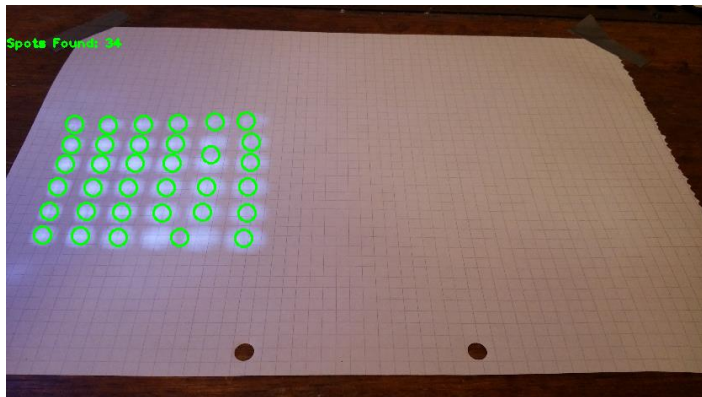# RESULTS

Many White Spots

HSV Method

- **Required for precision and speed**

- **Too close & too dim**

- **Multiple spots seen as one**

- **Distortion caused spots to blur together**

Spots Found: 12

Spots Found: 30

Spots Found: 26
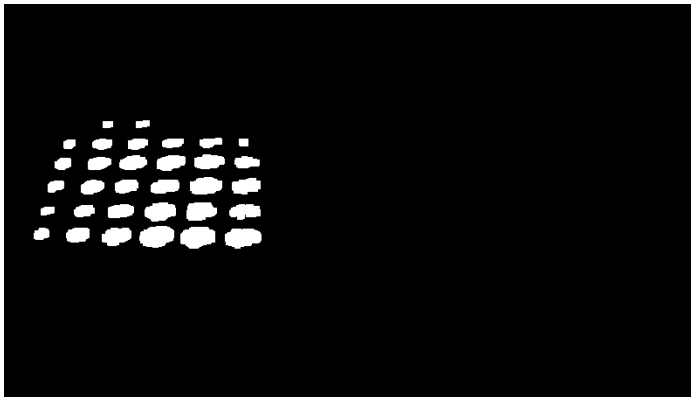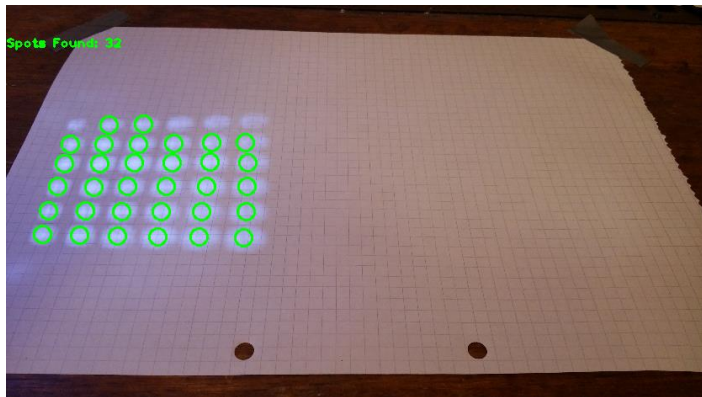
RESULTS

Many White Spots

Difference Method

- **Spots initially bright enough to be found**

- **Dilation reduced to prevent merging together**

- **Blurring became too significant – dilation was required**

FURTHER INVESTIGATIONS

- Test with more appropriate surfaces

- Different Algorithms

- Mirror Shape, Size, Colour.

- Effects of the Environment

CONCLUSION

- Possible to track light spots in simple situations

- Algorithm needs to be improved

- The surface properties of the target environment need to be accounted for

- Reliability and Robustness needs to be improved

ACKNOWLEDGEMENTS

- Dr Tony Cook

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