Vision report

Functional requirements

- Avoids obstacles effectively.

- Measures positions of balls.

- Transmits ball information to control subsystem.

Non-functional requirements

- Can collect position and colour of balls given that:

1. the distance is within 20cm - 80cm

2. the angle is less than 45 degrees

3. the ball does not touch the edges of the frame

- In addition, balls can be detected (but data cannot be recorded) within:

1. distance greater than 14cm

2. angle smaller than 50 degrees

- Can identify colours of provided balls (red, pink, yellow, green, blue) under sunlight.

- Can accurately determine distance to balls under sunlight and lamp light.

- Automatic gain and exposure calibration to adapt to different light levels.

\*- Accelerometer data used to calculate inclination of rover.

- Accelerometer and camera can be calibrated remotely.

- Processes data 6 times per second.

- UART uses acknowledgement to ensure:

1. all messages are transmitted successfully

2. important messages are transmitted correctly

- UART uses a ‘loose’ handshake when transmitting data, meaning processor can process data, rather than sleep, when waiting for responses. This was chosen over a ‘firm’ handshake because this method is much more resilient against errant characters or missing characters in transmission.

- Uses dynamic arrays to allow system to easily scale to any number of balls if necessary.

Testing conditions

- Tested under sunlight(6500K?) and 3000K 5W LED lamp.

1. Varied brightness by varying distance to lamp or closing blinds partially.

2. Varied direction of lamp and sunlight by rotating camera and balls.

- Background was matte painted wall with wooden floor.

The image processor receives a stream of RGB pixel values from the camera, this was chosen over conversion to HSV because the hue varied greatly with lighting conditions, which led to poor ball detection and obstacle avoidance performance.

The image processor uses 'filters' to determine whether a given pixel could belong to a ball. There are two sets of these filters. The first set (ball detection filters) was designed to reduce the reporting of false negatives, across a wide range of lighting conditions, however, this set provides no data about the colour. For colour detection, a second set of filters (colour filters) was designed, this set contains five filters, one for each ball colour. The colour filters have a very low chance of reporting false positives under sunlight.

Data from the filters is accessible to the NIOS II processor through a FIFO message buffer. This includes words containing the bounds of any balls detected, as well as the bounds of each of the five colour filters.

The NIOS II processor removes errant data from the detected balls, then combines the data with the bounds of the colour filters, to recognise the colours and positions of all visible balls. If a ball is in the path of the rover, and the rover is currently moving, a signal is transmitted over UART to stop the drive subsystem, along with data of the problematic ball. Otherwise, if a new ball is visible, but has not been seen before, its data will be transmitted to the command subsystem.