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## WAES3102 Fundamentals of Robot Intelligence

Colour Based  
Rovio



PREDATOR

Object Tracking with

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## 1.0 Introduction

The WowWee Rovio is a commercially available telepresence robot. Essentially a Wi-Fi-enabled mobile webcam on wheels, the Rovio can be controlled from anywhere in the world through its Web-based interface. Its features include wheeled locomotion, a webcam, microphone and speaker, infrared object detection, 802.11g wireless, and more. The Rovio firmware includes an on-board web server that can be used to programmatically control the robot by any software that implements the API.

A variety of problems in computer vision require the ability to track moving objects in real time for purposes such as surveillance, video conferencing and robot navigation. One of the well-known method to track moving objects is by its colour. Colour has been widely used in real-time tracking systems as it offers significant advantages over geometric cues such as computational simplicity.

For this project, we decided to enable a WowWee Rovio robot to detect, track and chase a moving coloured object of interest.



## 2.0 Project Details

### 2.1 Project Objectives

The aim of this project is to enable Rovio:

- To detect presence of coloured object
- To track the movement of coloured object
- To chase the coloured object as it moves

### 2.2 Project Scopes

Rovio will be able to detect, track and chase coloured object in a well lit and obstacle-free environment.

### 2.3 Tools Needed

#### **Hardware:**

- WowWee Rovio robot
- Laptop

#### **Software:**

- Pycharm (Python IDE)
- Web browser



## 3.0 Overview

### 3.1 Detection and Movement Tracking of Coloured Object

Object detection and segmentation is the most important and challenging fundamental task of computer vision. Therefore, the quickest and most efficient method is colour detection. Colour detection is one of the many object detection methods that we can apply in a robot. In this project, the colour detection filter can be RGB or HSV. By setting the filter, the Rovio is able to track the movement of the colour object.

### 3.2 Chasing the Coloured Object

After object detection and tracking, the program able to make Rovio chase the coloured object that has been detected earlier. The Rovio is set-up to keep its distance between the coloured object in an optimum range where if Rovio is placed too near to the coloured object, it must be able to move backwards away from the coloured object and keep the optimum distance.

## 3.3 Networking

### 3.3.1 Internet Protocol v4 Address

To connect with Rovio, we are using Ad-Hoc setup by creating host network and letting Rovio connect to the network. For that, we are required to change the IP address in the PC to the specified IP address. IP (short for Internet Protocol) specifies the technical format of packets and the addressing scheme for computers to communicate over a network. IP by itself can be compared to something like the postal system. It allows you to address a package and drop it in the system, but there's no direct link between you and the recipient. TCP/IP, on the other hand, establishes a connection between two hosts so that they can send messages back and forth for a period of time.

### 3.3.2 Subnet Mask

Same as the IP address, we need to change the Subnet Mask in the PC to certain address to be able to connect to the hosted network. Subnet mask is a mask used to determine what subnet an IP address belongs to. An IP address has two components, the network address and the host address.

## 4.0 Project Implementation

### 4.1 Set-up Rovio

#### 4.1.1 Connect to Rovio (Window 7 & Linux(OSX))

1. To make sure the Rovio is in default condition, press the turn on button and turn it off when the LED light starts to light up (orange colour) for four times or until the LED light on the button blinks with different colours. This is to make sure that Rovio is in default condition where the SSID it broadcasts will change to **"ROVIO\_WOWWEE"** with no authentication needed.
2. On the laptop or desktop, assign IP address to your network interface card statically (Range: **192.168.10.2~.254**, **192.168.10.18 is not allowed**; Subnet mask: 255.255.255.0) and connect to the SSID named **"ROVIO\_WOWWEE"**.
3. In the **web browser**, type in URL **"192.168.10.18"** which is the default IP address for Rovio.
4. Finally, the user should be able to see the web graphical user interface to control Rovio. User can go to the settings to change the SSID that Rovio broadcasts and also the user can also select the SSID that Rovio should connect to.

#### 4.1.2 Create hosted network (Window 8 and above)

1. In some cases, Windows 8&10 users might not be able to connect to the network Rovio broadcasts. This might be due to the outdated driver of the Qualcomm Atheros Network Adapter. Therefore, these users can broadcast a network and request Rovio to connect to the network instead.
2. Change IP Address and subnet mask (Most probably 192.168.173.1) then open Command Prompt (Run cmd.exe) in Windows.
3. Type **"netsh wlan set hostednetwork mode=allow ssid=xxx key=yyy"**. (Please replace xxx as your own network ssid name and yyy as the password, created the SSID & password yourself)
4. Then, type **"netsh wlan start hostednetwork"**. (You will be able to see the output in the command line that shows that the hostednetwork is started)
5. Check the network address of the network in command line using ipconfig. **(Referred to Rovio Window 8 & Above.docx)**
6. Connect the Rovio to the computer using Windows 7 or Linux(based on setup 4.1.1), click Setting - > Network - > reset the connected SSID as xxx (what you have set earlier) and assign a static IP address with network mask according to the network that you have set earlier.



7. After Rovio restarts, the user should be able to access the controller page when accessing the Rovio IP address in the web browser.

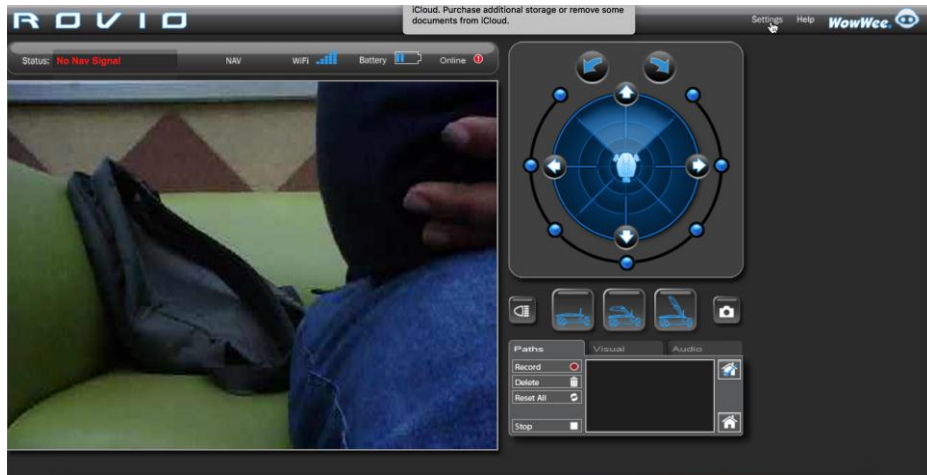


Figure 1: For Step 6: Connect to Rovio using Window 7 or Linux and open 192.168.10.18 in browser

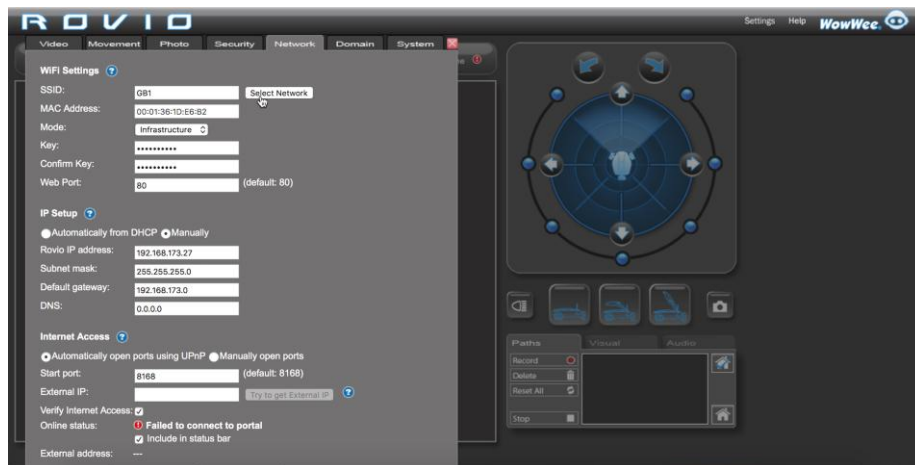


Figure 2: Step 6: Go to Setting -> Network -> Select Network that you has created earlier in command prompt

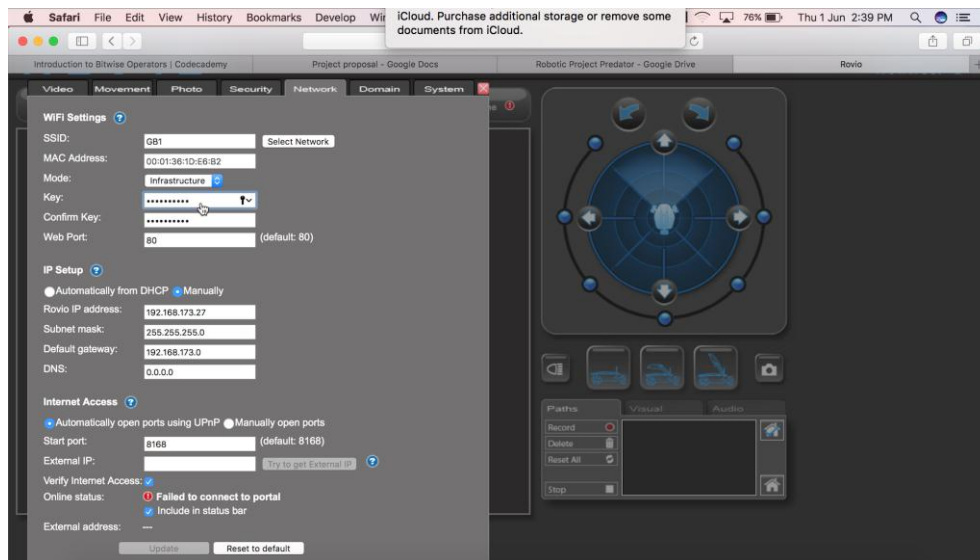


Figure 3: Step 6: Change the key to password that you have set earlier in the command prompt

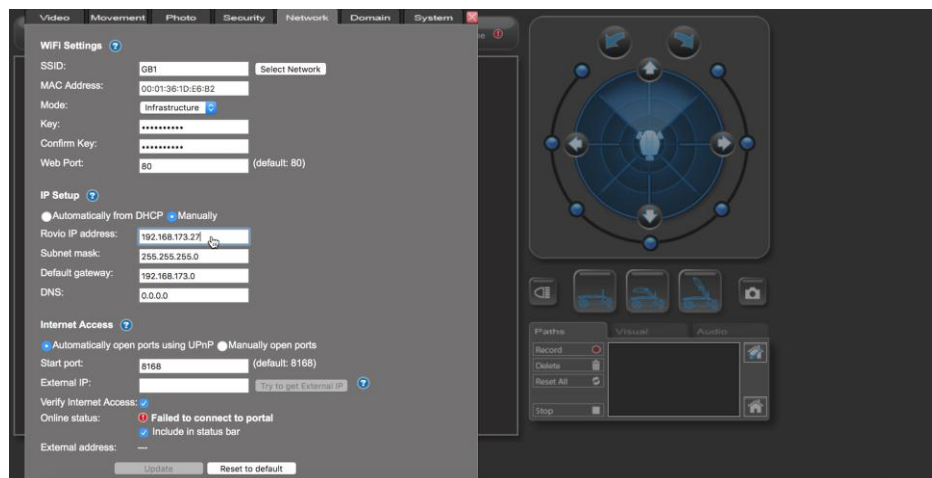



Figure 4: Step 6: Change the Rovio IP address to any address in the range of the network that you have set

### 4.1.3 Program the Robot in Python Environment

1. First of all, user must download and setup the Python environment.
2. User should download one of the Python IDEs, such as [PyCharm](#).
3. It is best for beginners to download [Anaconda](#) as the scientific library.
4. After installing Anaconda, change the IDE interpreter in PyCharm to the Anaconda Python interpreter.
5. Since this project involves a lot of image processing functions, users have OpenCV as their image processing library.
  - a. Download the [OpenCV](#) library.
  - b. Run the downloaded program and extract to Desktop.
  - c. Copy `cv2.pyd` (opencv/build/python/2.7/x64/cv2.pyd) and paste into (Anaconda2/Lib/site-packages).
  - d. Type the command below in the command line or terminal to check whether openCV library has been imported:  

```
>> python  
  
>>import cv2
```

- 
6. Download the source codes from the [Google Drive link](#) inside the Code folder
  7. Inside the test.py file (.py file containing the main function), it is required to change the SSID and password according to your settings for Rovio.
  8. Build your code.
  9. It is required to use the Anaconda prompt to run the program. Therefore, open the Anaconda prompt.
  10. To run the program, navigate(cd) to the directory where test.py is located.
  11. Run test.py by using the command below inside the Anaconda prompt:  

```
>> python test.py --filter HSV --webcam
```

  
(use --filter RGB if you wish to use the RGB color space)

## 4.2 Algorithm Implementation

### 4.2.1 Colour Object Detection & Tracking

For Rovio to chase an object, it needs to be able to detect and track the movement of the object first. To do this we use one of the simplest method to detect an object in computer vision, which is to detect the object by colour. This can be done in both the RGB and HSV colour spaces.

For the purpose of this project, we decided to use the HSV colour space. The reason why is because HSV separates the image intensity from the colour information. This is very useful when you want robustness to lighting changes. In a way, HSV colour space is more likely to have less problem dealing with changing illumination and shadowing of the environment compared to the RGB colour space. This is because the hue component of an object under different illumination is more likely to be similar (the shadow will primarily influence the value, or the saturation component while the hue should not change much). Another reason is simply because the code for converting between RGB and HSV is widely available and can also be easily implemented.

The first step is to obtain the camera frame from Rovio. What comes next is the preprocessing of the frame image where we resize the image (for faster processing) and

convert its colour space from RGB to HSV. Next, in order to detect the colour object, the user is required to input the desired minimum and maximum values of the HSV components for the object to be detectable (Refer Figure 5).

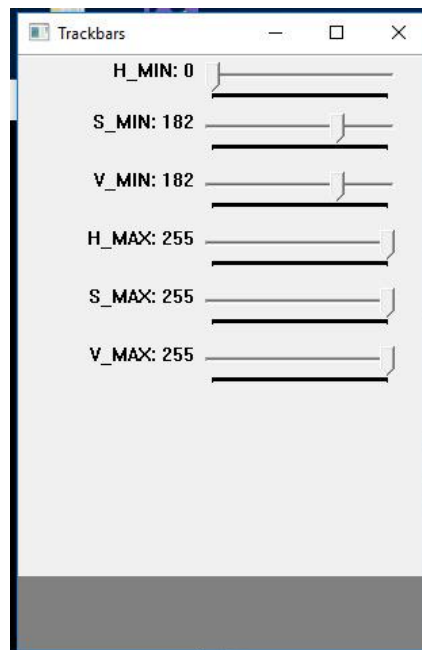


Figure 5: Trackbar to input the HSV components range values

Using the values inputted by the user, the next step is to filter the colour object by thresholding the frame image. From there on, noises are removed from the thresholded image and contours in the mask are detected. If there are contours found (suggesting that the object of interest exist and can be detected), the biggest contour in the frame is detected and a circle and centroid of the object is drawn

onto the frame (Refer Figure 6). For every subsequent image frame, this process repeats allowing Rovio to track the object of interest (Refer Figure 7).

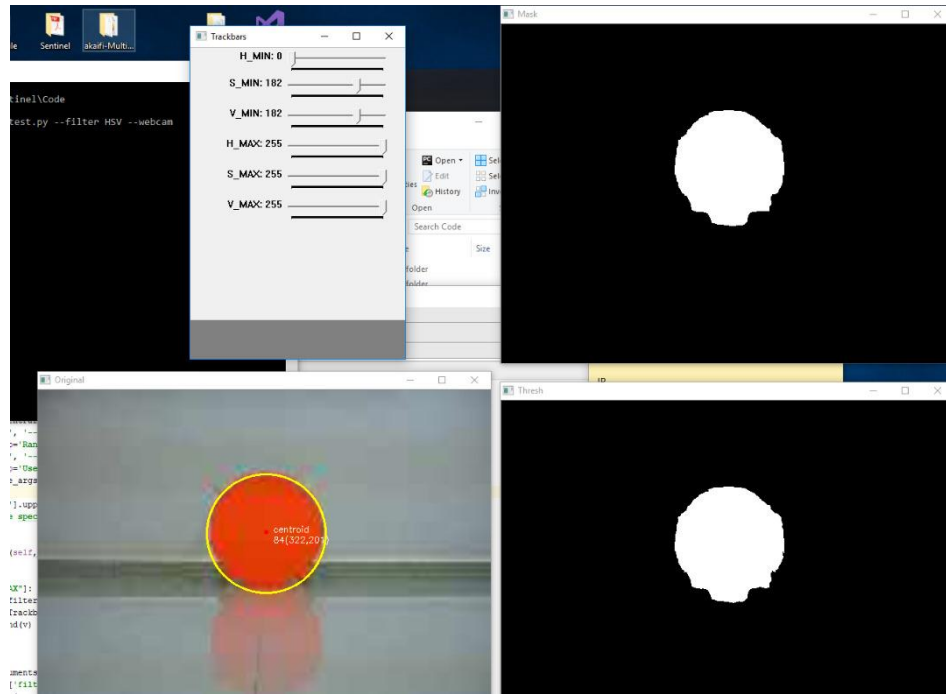


Figure 6: Circle and centroid of colour object drawn onto original frame

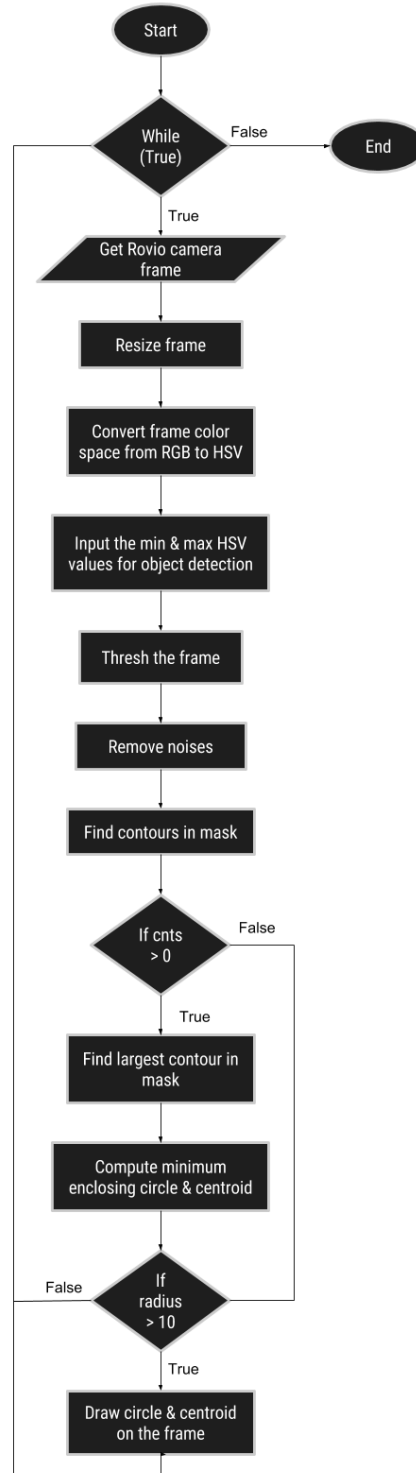




Figure 7: Flowchart of colour object detection and tracking process

#### 4.2.2 Object Chasing

After detecting and tracking the colour object, Rovio should be able to chase after it. This is done by constantly comparing the radius of the colour object of interest in each subsequent camera frame. If the object is getting further away (suggested by smaller radius), Rovio will be able to move forward and towards the object. If the object is too near (suggested by bigger radius), Rovio will be able to move backwards to keep an optimal distance between the object and itself (Refer Figure 8).

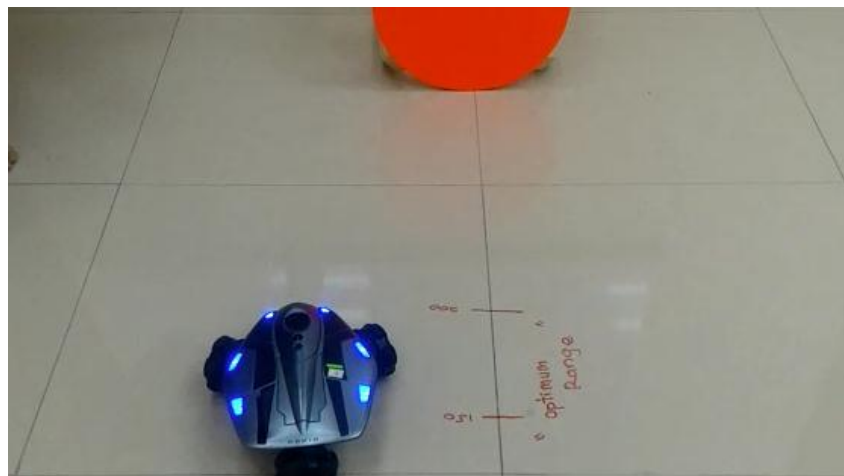
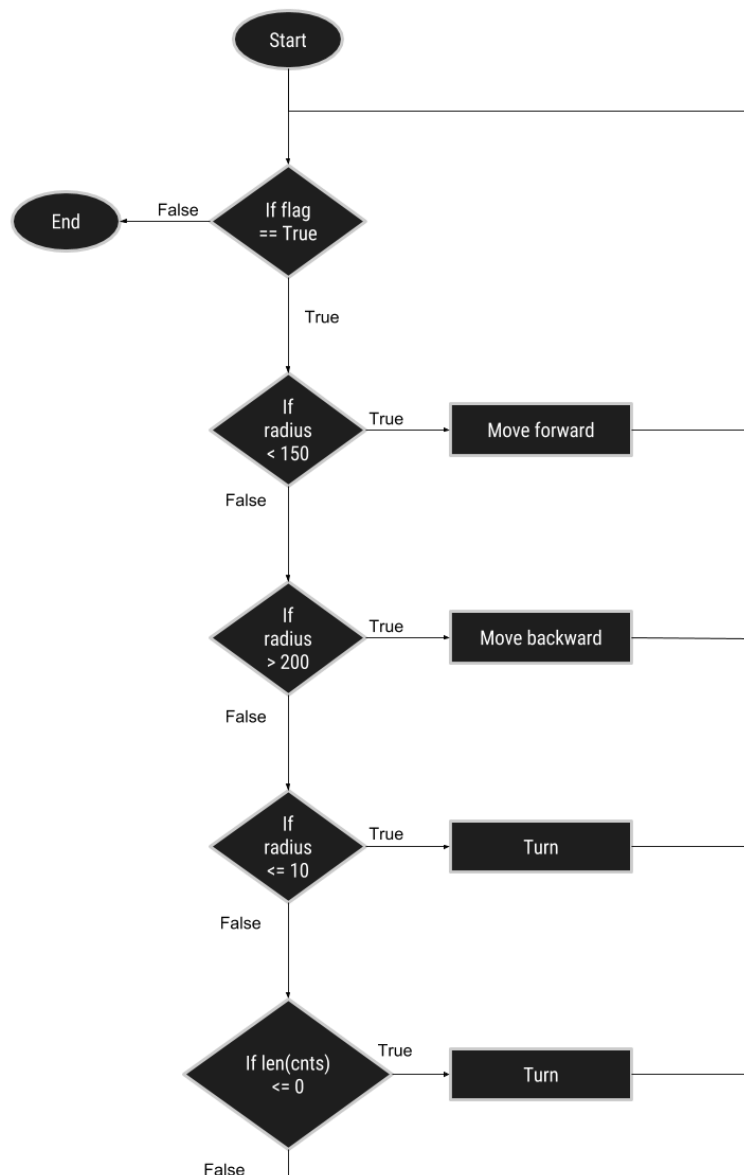


Figure 8: Rovio keeping an optimal distance from colour object of interest

Next, if the object is taken out of Rovio's view (radius is below 10 or contour not found), Rovio will be able to turn around

and search for the object in its environment and proceed to chase



after that object (Refer Figure 9).



Figure 9: Flowchart of colour object chasing process

## 5.0 Evaluation

### 5.1 Comparison with Roborealms

OpenCV	Feature	RoboRealm
Not Available	Expiration	15 days
Own Implemented	Floor Finder	Library
Not Available	Music Player	MIDI player
Adjustable	Degree of turning	Not adjustable

### 5.2 Obstacle Detection

The challenges faced in the project are:

1. Changes in factors such as illumination and shading may cause the object to be no longer detectable. It may cause the hue of the object to change and thus making it fall out of the detectable threshold range.
2. If another object that has the same hue characteristics and is of bigger size than the object being tracked entered the camera frame, the bigger object will be tracked instead.
3. Rovio will not be able to detect and avoid obstacles in its way.

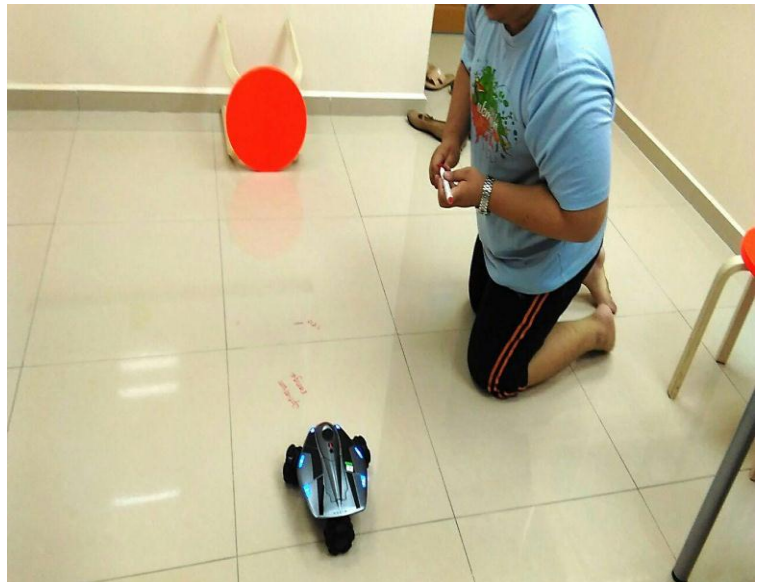


6.0 Photos









## 7.0 References

G. (2016, December 17). Object tracking by color (Python OpenCV). Retrieved May 31, 2017, from <https://www.youtube.com/watch?v=aHTVDoOWYB8>

Why track colors? (n.d.). Retrieved May 31, 2017, from [http://www.roborealm.com/tutorial/color\\_object\\_tracking\\_2/slide010.php](http://www.roborealm.com/tutorial/color_object_tracking_2/slide010.php)

Fernando, S. R. (n.d.). OpenCV Tutorial C. Retrieved May 31, 2017, from <http://opencv-srf.blogspot.my/2010/09/object-detection-using-color-seperation.html>





### **In Windows 8/8.1/10 and above**

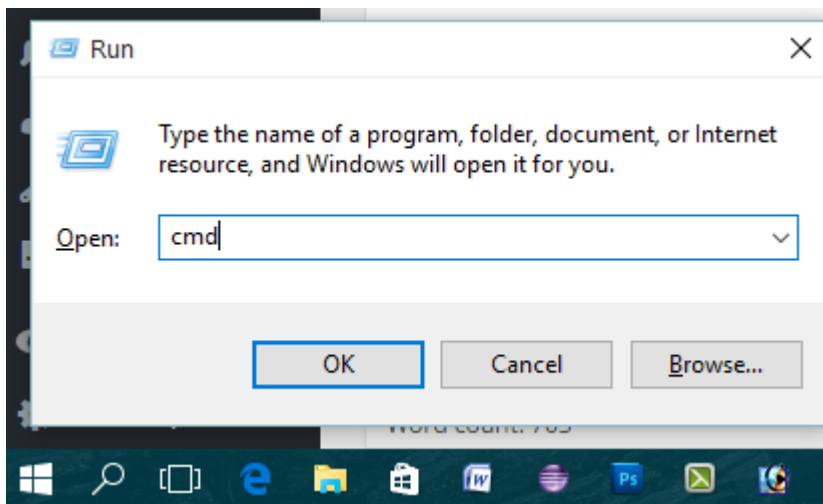
#### **1. Get a computer with Windows 7**

Get a computer with Windows 7 because we need it to connect to the Rovio robot the first time and change the ip address.

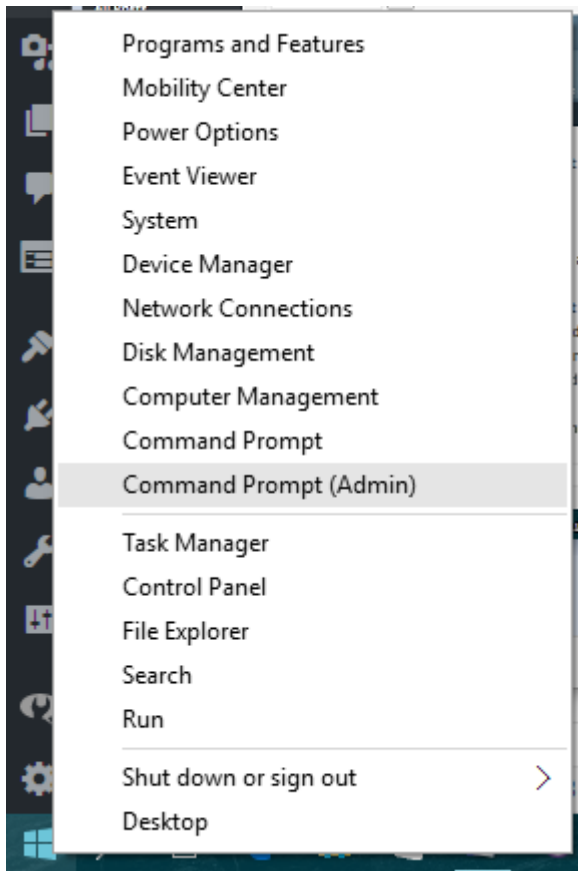
#### **2. Create a network on Windows 8 or above computer**

First, open command prompt in your computer.

**Open command prompt using Run** – Press Windows Key + R and type in cmd in the Run dialogue box and hit enter.



**Open Command prompt from Start** – Right click on Start button and select Command Prompt (Admin). This should open the command prompt in administrative mode. Or press Windows key + X and select Command Prompt (Admin).



In the command prompt Window, type the following command and press Enter:

**netsh wlan set hostednetwork mode=allow ssid=GB1 key=groupbee1**

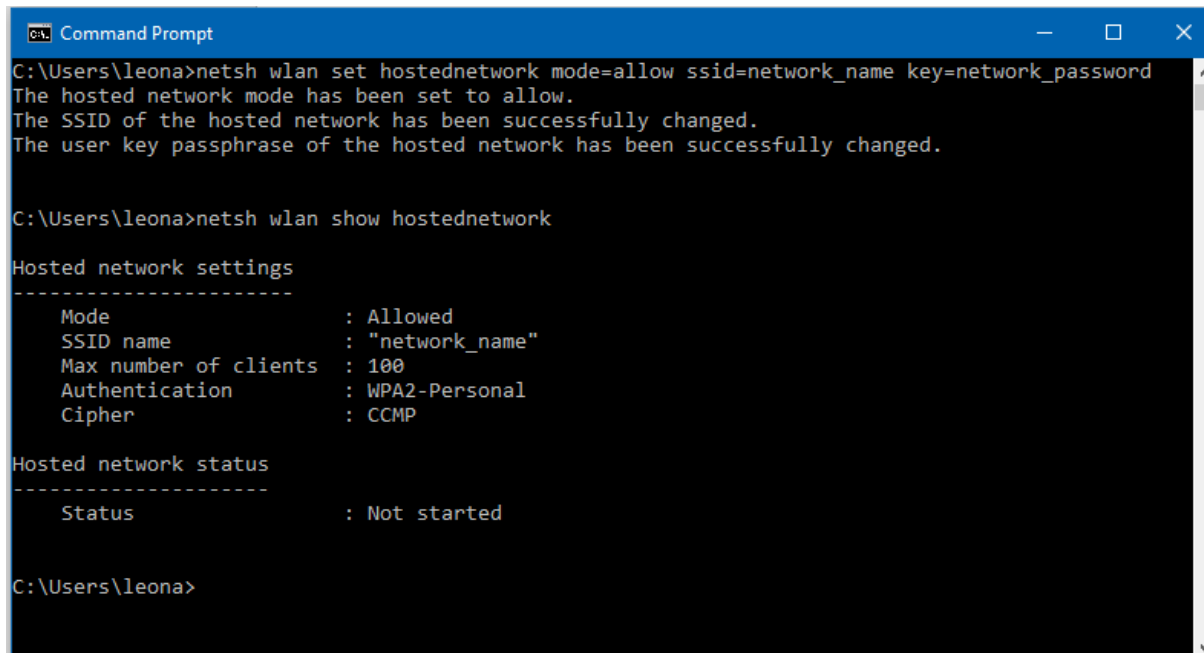
**\*\* NOTE:** the network\_name in ssid can be replace any name you want your network to be and the network\_password in key is the password of your network

```
Command Prompt
Microsoft Windows [Version 10.0.10586]
(c) 2015 Microsoft Corporation. All rights reserved.

C:\Users\leona>netsh wlan set hostednetwork mode=allow ssid=network_name key=network_password
The hosted network mode has been set to allow.
The SSID of the hosted network has been successfully changed.
The user key passphrase of the hosted network has been successfully changed.

C:\Users\leona>
```

After that, you can type **netsh wlan show hostednetwork** to show the network you have created.



```
C:\Users\leona>netsh wlan set hostednetwork mode=allow ssid=network_name key=network_password
The hosted network mode has been set to allow.
The SSID of the hosted network has been successfully changed.
The user key passphrase of the hosted network has been successfully changed.

C:\Users\leona>netsh wlan show hostednetwork

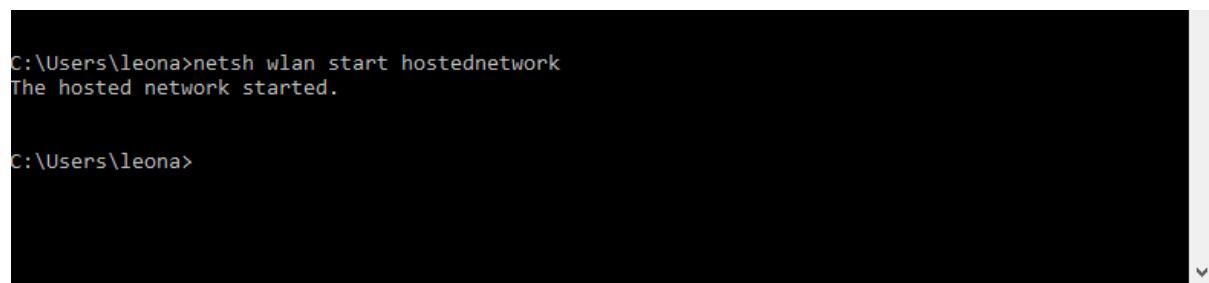
Hosted network settings
-----
Mode                : Allowed
SSID name           : "network_name"
Max number of clients : 100
Authentication      : WPA2-Personal
Cipher              : CCMP

Hosted network status
-----
Status              : Not started

C:\Users\leona>
```

Next, type in the following command to start the network:

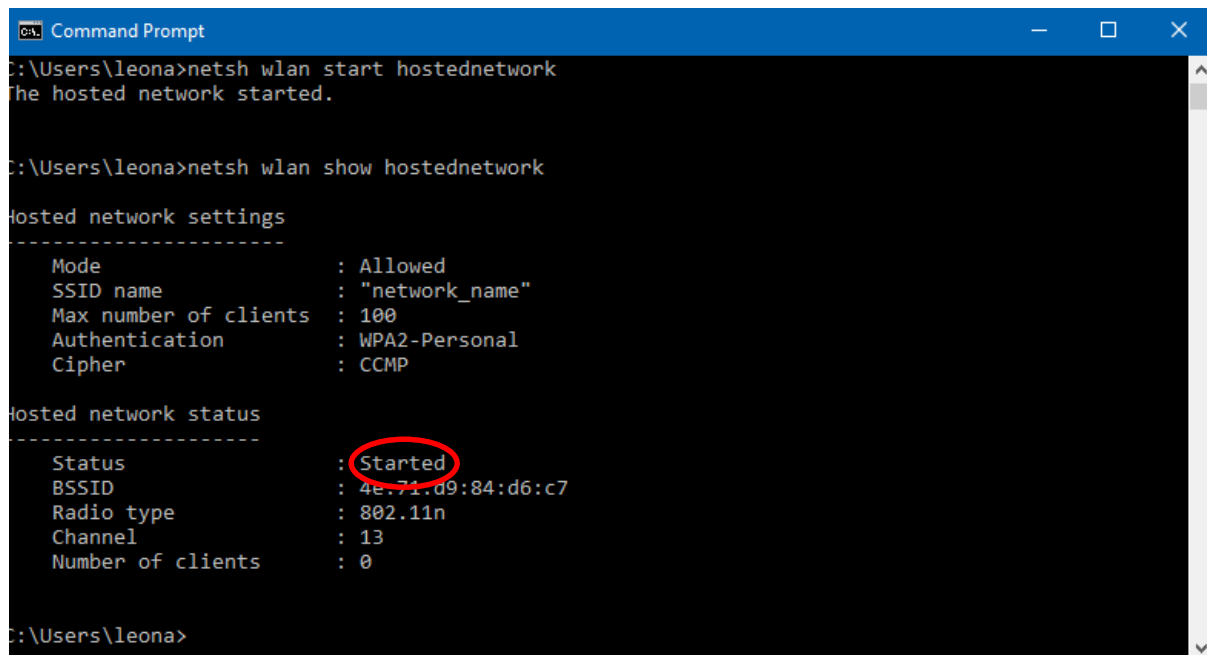
**netsh wlan start hostednetwork**



```
C:\Users\leona>netsh wlan start hostednetwork
The hosted network started.

C:\Users\leona>
```

After that, you can ensure your network is started by using the show command **netsh wlan show hostednetwork** and check the status.



```
Command Prompt
C:\Users\leona>netsh wlan start hostednetwork
The hosted network started.

C:\Users\leona>netsh wlan show hostednetwork

Hosted network settings
-----
Mode                : Allowed
SSID name           : "network_name"
Max number of clients : 100
Authentication       : WPA2-Personal
Cipher              : CCMP

Hosted network status
-----
Status              : Started
BSSID               : 4e:71:d9:84:d6:c7
Radio type          : 802.11n
Channel             : 13
Number of clients    : 0

C:\Users\leona>
```

**\*\* NOTE:** The network will be turn off when the computer is turn off. To start the network again, open command prompt and type **netsh wlan start hostednetwork**. No need to create the network again once the network is created.

### 3. Reset the Rovio robot - **Can Skip This one**

Turn on the Rovio robot, when see the light is shown then turn it off immediately. Repeat this step 3 times until you see the light is blinking.

### 4. Connect to Rovio network - **Can skip just connect to ROVIO\_X(rovio number)**

In Windows 7 computer, open your network and you will see ROVIO\_WOWWEE network in the list. Connect to ROVIO\_WOWWEE network.

### 5. Open Rovio robot controller interface

Open a web browser and go to this address: [192.168.10.18](http://192.168.10.18). The address is Rovio default address after it has been reset.

#### 6. Change the Rovio address. –

In the Rovio controller interface, click the setting on the top right corner. After the setting is shown, go to the network tab. On the first section, click the network button and a list of network will pop out. Choose the network name that has been created on the Windows 8 or above. Double click the network to connect to the network. Type in the password that is set to the network.

You should able to see a column name “ip address” on the second section of network tab. The default address is [192.168.10.18](http://192.168.10.18). You can change the address to [192.168.173.XXX](http://192.168.173.XXX). XXX is a number from range 2 – 254. [192.168.173.1](http://192.168.173.1) is not able to use because this is the network address on the Windows 8 or above computer. On the next column, change the subnet mask to [255.255.255.0](http://255.255.255.0). For default gateway column, leave the column blank.

Last, click the “Update” button on the bottom of the page and wait for 30 seconds.

#### 7. Control Rovio in Windows 8 or above

After 30 seconds, you are able to connect your Windows 8 or above computer to the Rovio. Open a web browser and type in the address that you have set to the Rovio: [192.168.173.XXX](http://192.168.173.XXX). Now you should able to connect to Rovio controller interface. For other computer to connect to the Rovio, they need to connect to your network. Let say the network created on Windows 8 or above is called my\_Rovio. They need to connect to my\_Rovio and type in the address [192.168.173.XXX](http://192.168.173.XXX) to connect to the Rovio because the Rovio is already set to the Windows 8 or above network.

**\*\* NOTE:** If the particular Rovio is reset, a Windows 7 computer is needed to configure the Rovio again.