Basic of Robotics

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CONTENTS

What is Robotics?

Defination of a Robot: Machines controlled by computers that are used to perform jobs automatically. [1]

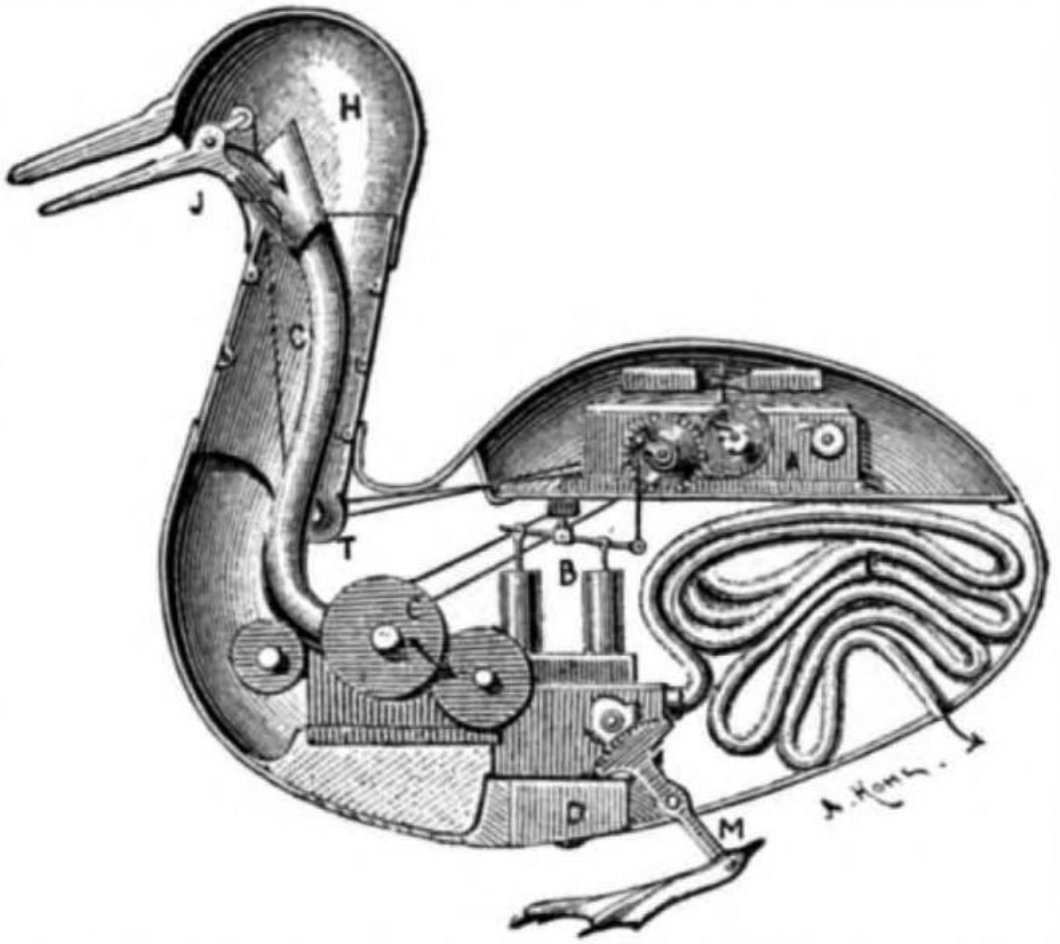
Defination of Robotics: the science of making and using robots. [1]

[1].Cambridge Dictionary. Accessed on 22-10-2023. https://dictionary.cambridge.org/dictionary/english/robotics.

History of Robots

Year:1739

"Digesting Duck" was created by Jacques de Vaucanson in 1739 [2].



INTERIOR OF VAUCANSON'S AUTOMATIC DUCK.

A, clockwork; *B*, pump; *C*, mill for grinding grain; *F*, intestinal tube; *J*, bill; *H*, head; *M*, feet.

[2]. Carr, Dr Steven M. Digesting Duck, www.mun.ca/biology/scarr/4270_Reductionism.html. Accessed on 22-10-2023.

History of Robots

Year:1921

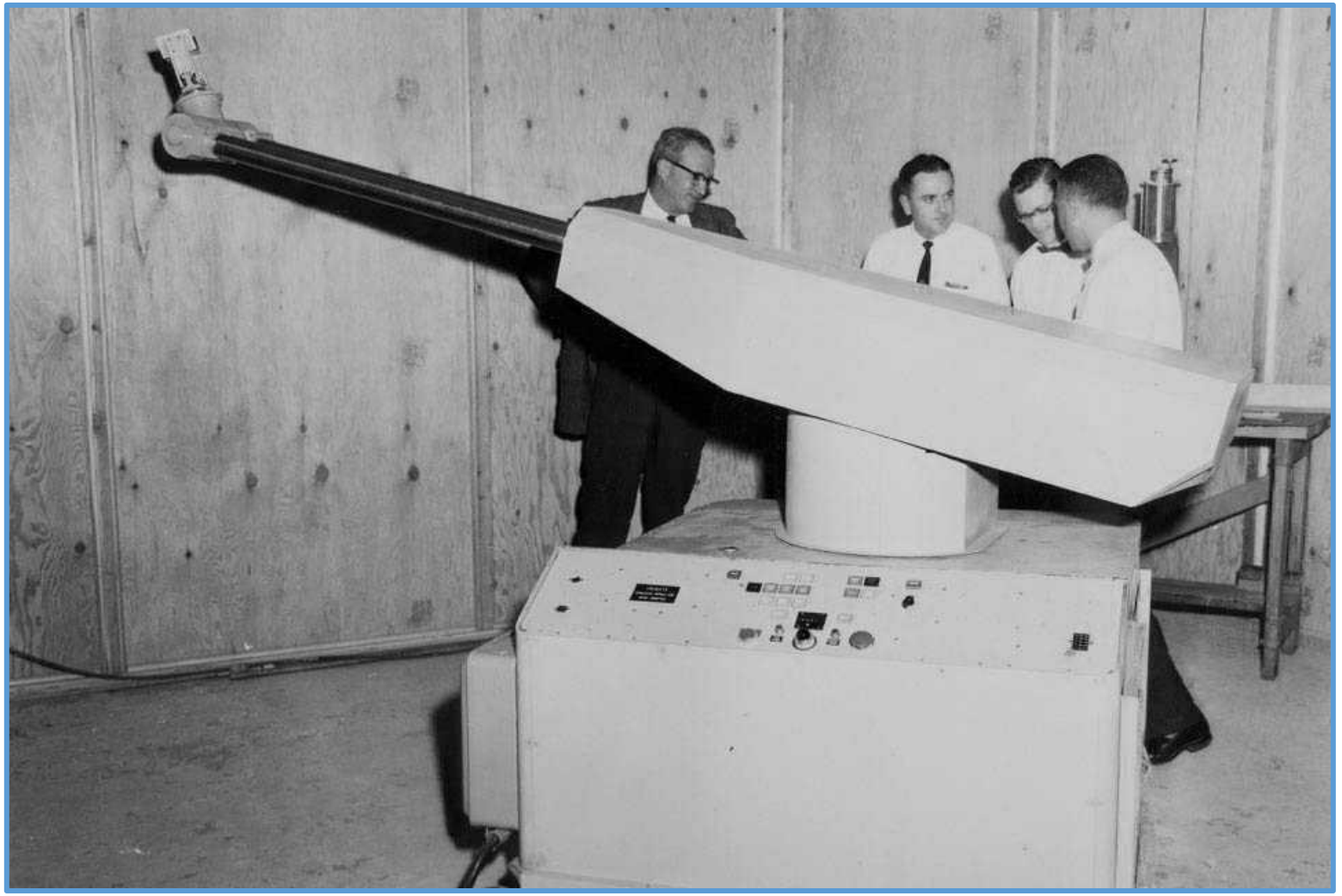
In his play “R.U.R.: Rossum’s Universal Robots,” the Czech writer Karel Čapek tells the tale of a factory in which thousands of synthetic humanoids have been created [2].

[2]. Carr, Dr Steven M. Digesting Duck, www.mun.ca/biology/scarr/4270_Reductionism.html. Accessed on 22-10-2023.

History of Robots

Year:1959

First robotic arm is installed on a factory floor [2].



[2]. Carr, Dr Steven M. Digesting Duck, www.mun.ca/biology/scarr/4270_Reductionism.html. Accessed on 22-10-2023.

Robots In the Agriculture Industry

Seeding and Spraying Robots

Drones for seeding and spraying are still a new thing, but they are commercially available [3].

[3]. Agricultural Robots: A revolutionary tool for farmers worldwide.https://howtorobot.com/expert-insight/agricultural-robots. Accessed on 22-10-2023.

Fruit and Vegetable Harvesting Robots

Fruit and vegetable harvesting robots are still in the prototype stages. They show great promise [3].

[3]. Agricultural Robots: A revolutionary tool for farmers worldwide.https://howtorobot.com/expert-insight/agricultural-robots. Accessed on 22-10-2023.

Aerial Imaging Robots

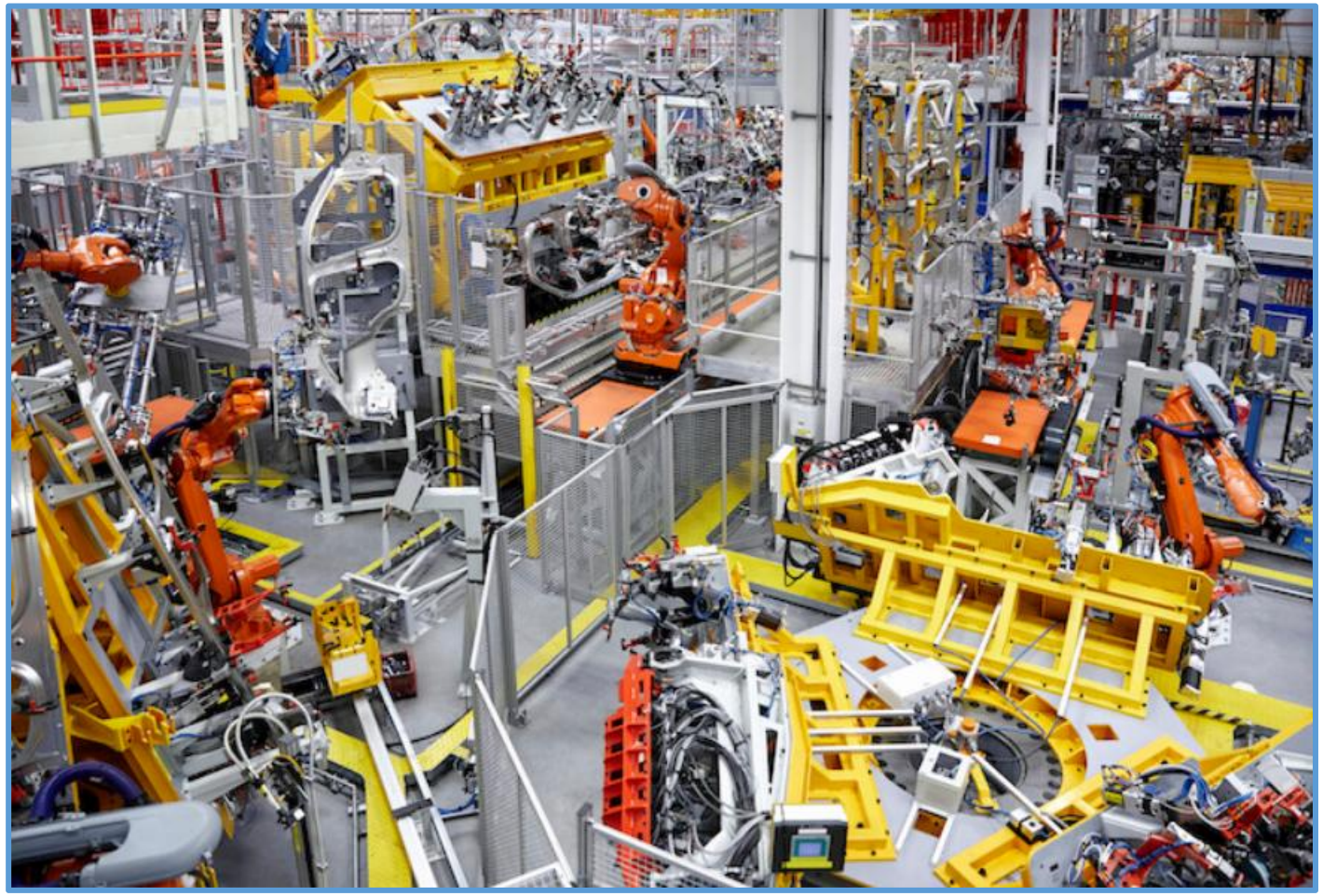
Using aerial drones to inspect crops from the air is well established. Aerial imaging produces valuable insights into crop health and soil conditions [3].

[3]. Agricultural Robots: A revolutionary tool for farmers worldwide.https://howtorobot.com/expert-insight/agricultural-robots. Accessed 22 Oct. 2023.

Robots In Industries

Robots In Manufacturing

From factories to farms, there are a growing number of places and situations where industrial robots can be adapted to perform [4].

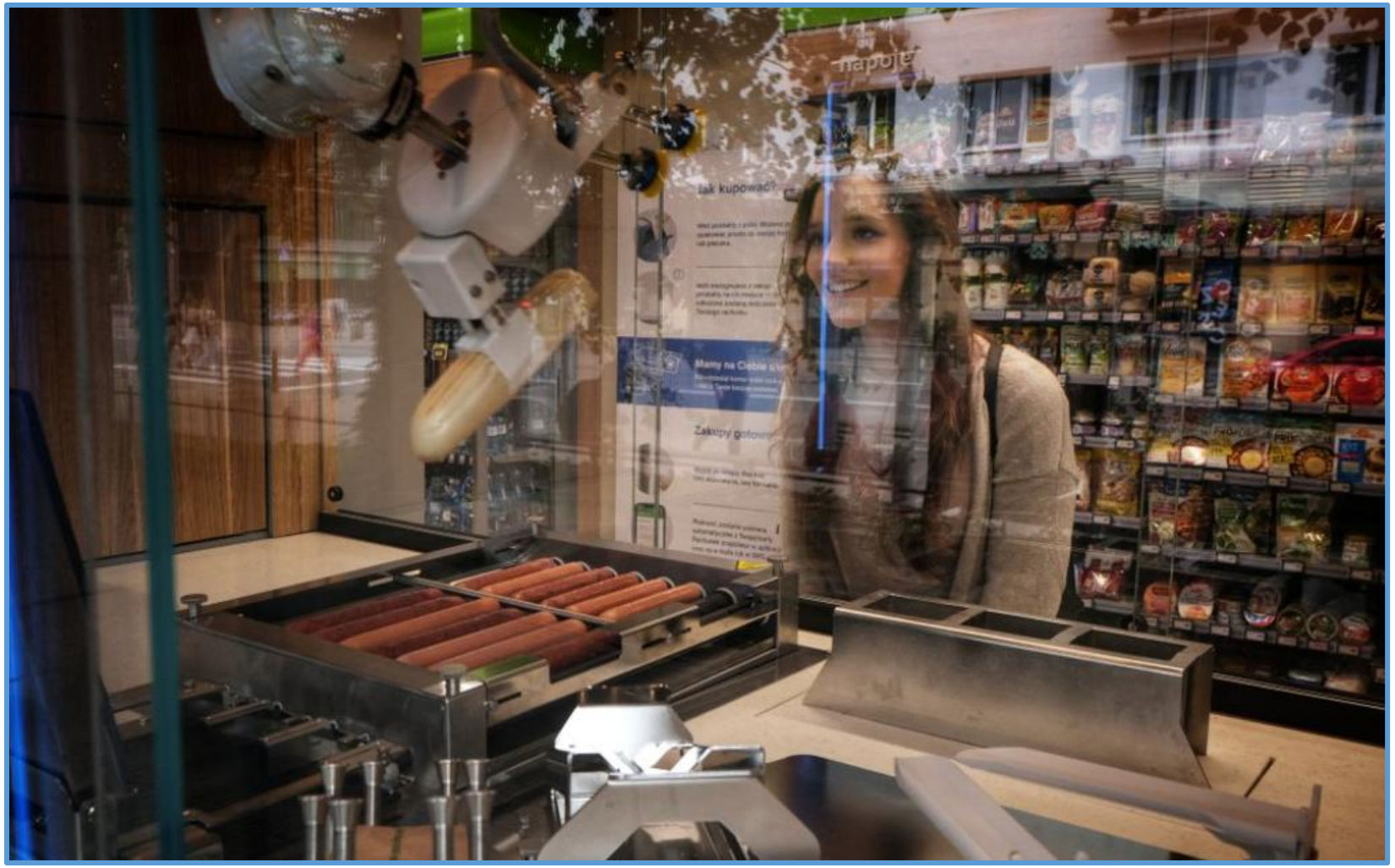


[4]. The good, the bad, and the ugly of Industrial Robots In Manufacturing. Industrial Robots: Manufacturing Examples. https://www.autodesk.com/design-make/articles/industrial-robotics. Accessed on 22-10-2023.

Robots In Food Industries

Poland introduces hot dog-making robot

The brainchild of convenience store chain Żabka and Kraków tech firm VeloxAlpha SA, the one-armed sausage server called Robbie can complete its task in three simple steps [5].



[5]. Robbie, Zabka's 24/7 Hot Dog-Making Robot, Debuts in Warsaw Convenience Store https://www.franchising.com /articles/robbie_zabkas _247_hot_dogmaking_robot_debuts_in_warsaw_convenience_store.html. Accessed on 22-10-2023.

Poland introduces hot dog-making robot

First the robotic arm pulls a bun out of a closed drawer compartment and puts it on a hot grill to heat and toast it. Then it takes out the bun and slips it under a tube that squirts in your condiment of choice [5].

[5]. Robbie, Zabka's 24/7 Hot Dog-Making Robot, Debuts in Warsaw Convenience Store https://www.franchising.com /articles/robbie_zabkas _247_hot_dogmaking_robot_debuts_in_warsaw_convenience_store.html. Accessed on 22-10-2023.

Poland introduces hot dog-making robot

Next the robot places the bun on a little metal bed and carefully slides the hot dog into it. The arm uses suctions to pick up a paper sleeve for the hot dog and slips it onto the bun.

[5]. Robbie, Zabka's 24/7 Hot Dog-Making Robot, Debuts in Warsaw Convenience Store https://www.franchising.com /articles/robbie_zabkas _247_hot_dogmaking_robot_debuts_in_warsaw_convenience_store.html. Accessed on 22-10-2023.

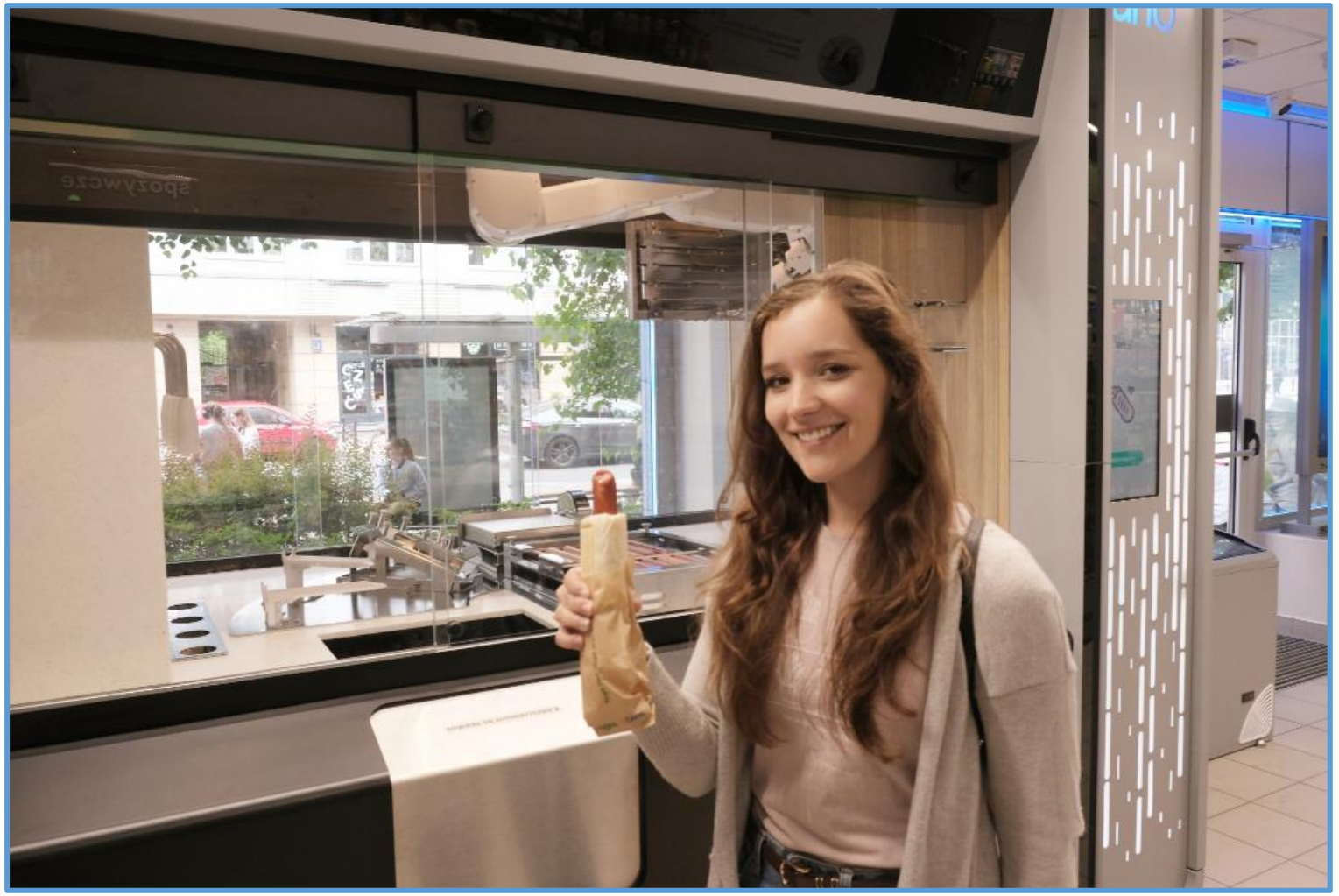
Poland introduces hot dog-making robot

Lastly, the robot picks the hot dog up and places it into a stand up tray which lowers and the door slides open when the whole process is finished so you can safely take it out.

[5]. Robbie, Zabka's 24/7 Hot Dog-Making Robot, Debuts in Warsaw Convenience Store https://www.franchising.com /articles/robbie_zabkas _247_hot_dogmaking_robot_debuts_in_warsaw_convenience_store.html. Accessed on 22-10-2023.

Poland introduces hot dog-making robot

Happy customer: Monica said the experience was quick and efficient but regretted that the company has yet to introduce a vegan version [5].



[5]. Robbie, Zabka's 24/7 Hot Dog-Making Robot, Debuts in Warsaw Convenience Store https://www.franchising.com /articles/robbie_zabkas _247_hot_dogmaking_robot_debuts_in_warsaw_convenience_store.html. Accessed on 22-10-2023.

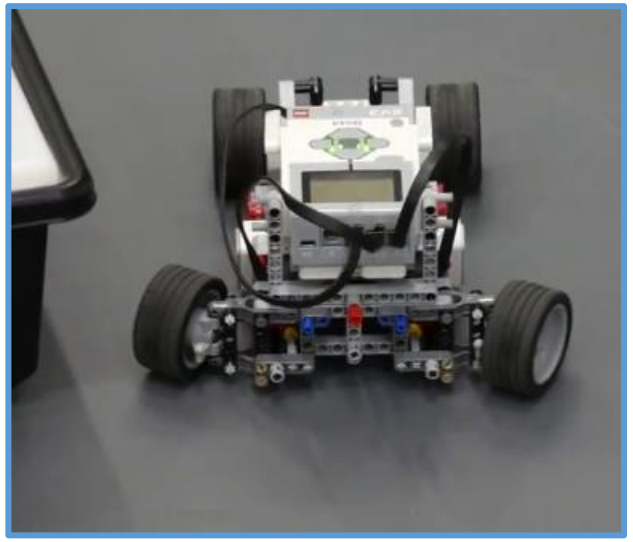
What is a Mobile Robot?

A mobile robot is a machine controlled by software that use sensors and other technology to identify its surroundings and move around its environment [6].

[6]. Tech Target netwrok. https://www.techtarget.com/iotagenda/definition/mobile-robot-mobile-robotics. Accessed on 22-10-2023.

Types of Mobile Robot

Car-like robot

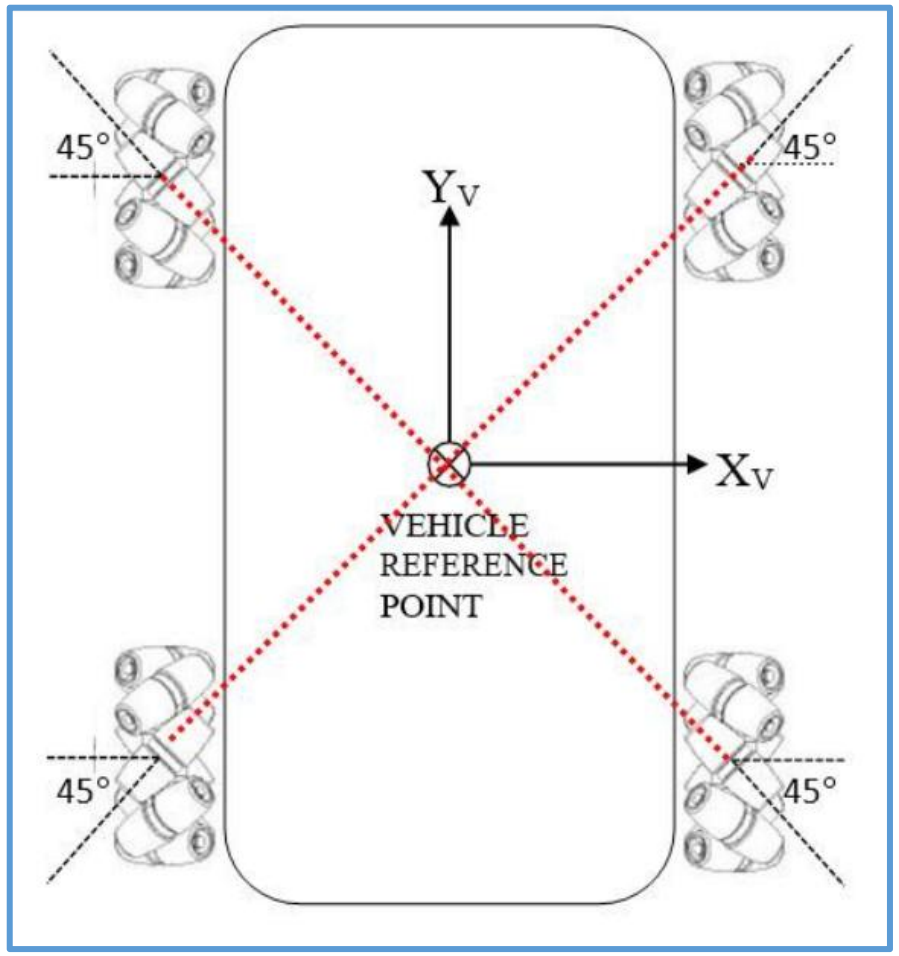


[7]

[7]

[7]. https://www.google.com/search?q=car+like+robot&sca_esv=575810318&tbm=isch&sxsrf=AM9HkKlRh0-qfjWqqFrCohNdG_Zbph8q3g:1698073474637&source=lnms&sa=X&ved=2ahUKEwi9gIjSuIyCAxWNSmwGHelpBa8Q_AUoAXoECAEQAw&biw=1536&bih=695&dpr=1.25#imgrc=MRESkn6Q-6WntM.

Omni-Directional Mobile Robot with Mecanum Wheels

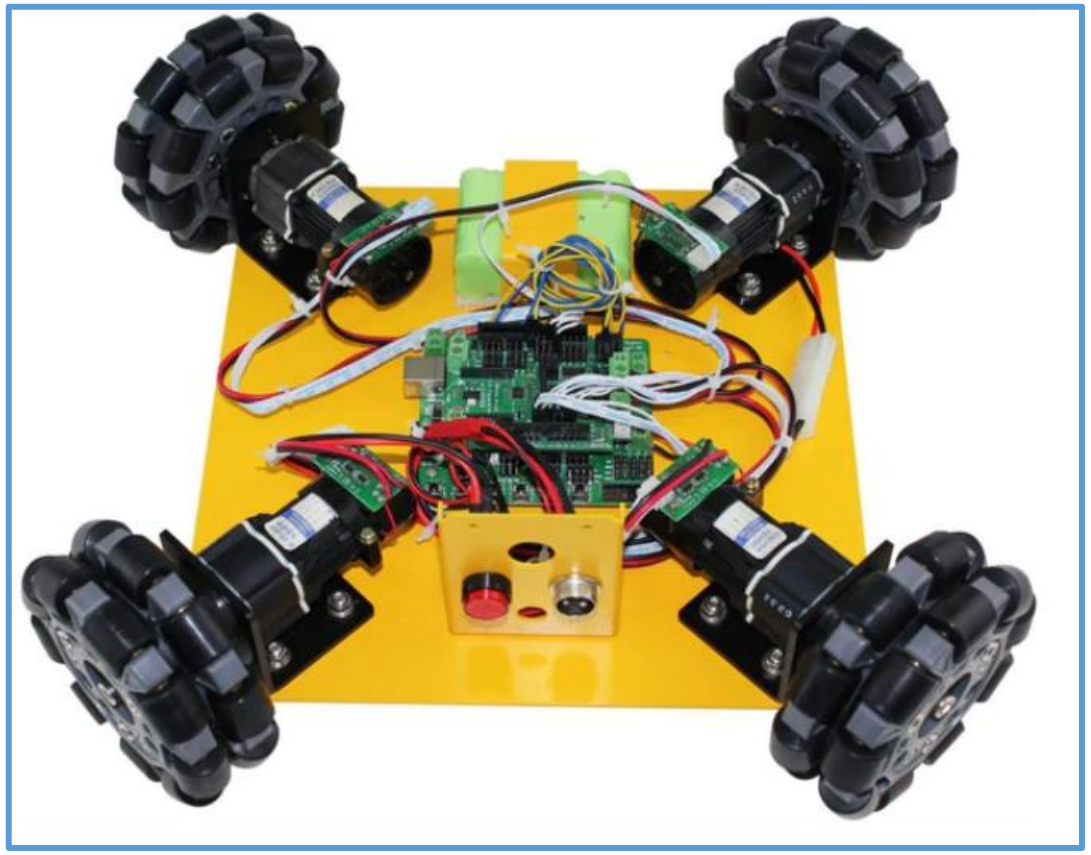


[8]

[8]

[8]. Force Vector Diagrams for an Omni-directional Mobile Robot. https://automaticaddison.com/force-vector-diagrams-for-an-omni-directional-mobile-robot/. Accessed on 22-10-2023.

Omni-Directional Mobile Robot with Mecanum Wheels



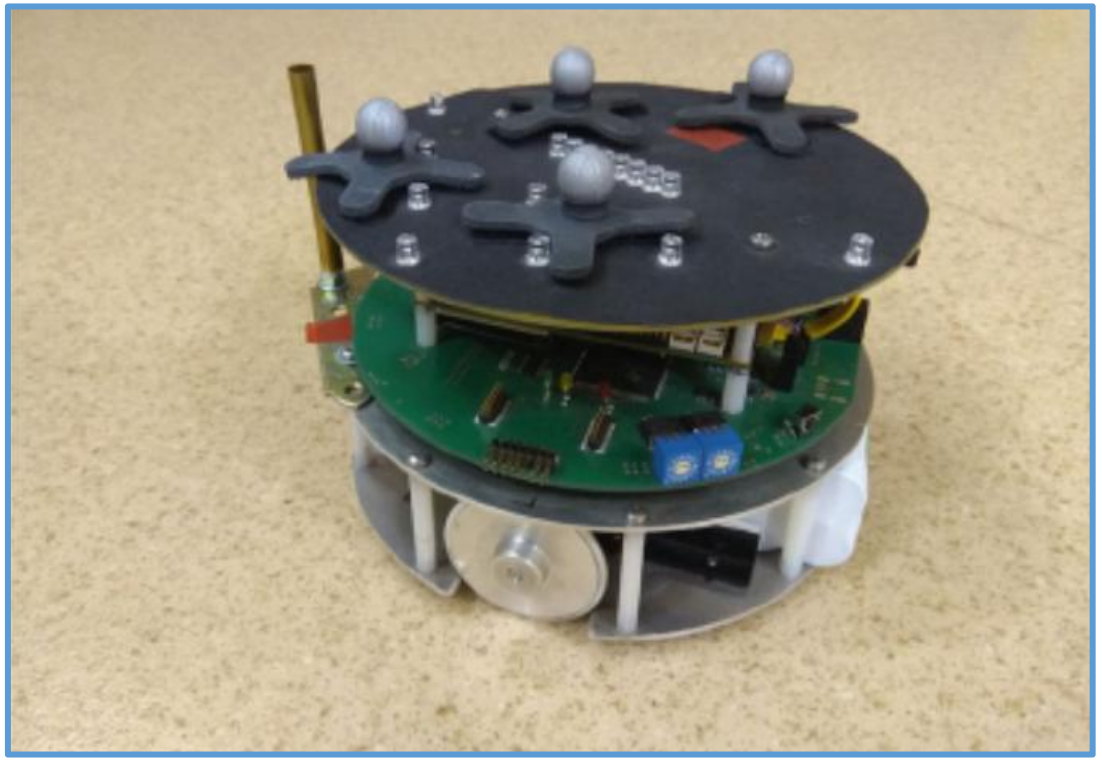
[9]

[10]

[9]. Robot shop. https://www.robotshop.com/products/4wd-omni-directional-arduino-compatible-mobile-robot. Accessed on 22-10-2023.
[10]. superdroidrobots. https://www.superdroidrobots.com/store/usage/programmable-robots/product=1486.

Unicycle-Like Mobile Robot / Two Wheeled Mobile Robot

[11]

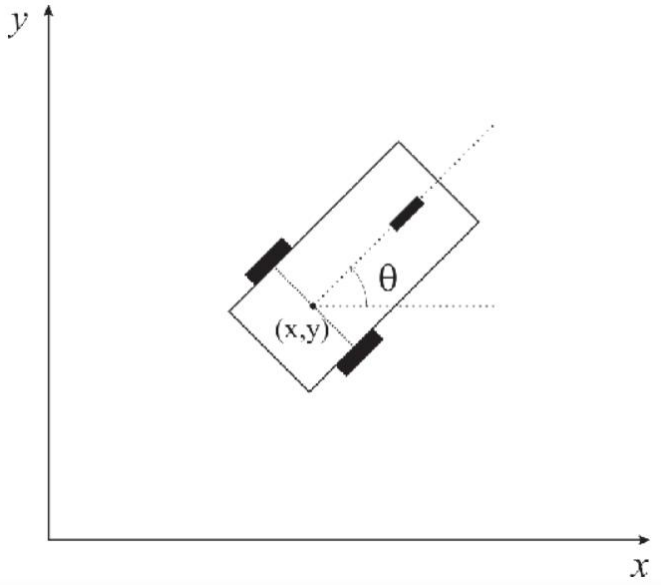


[12]

[11].Sun, Chung-Hsun et al. “Design of T-S fuzzy controller for two-wheeled mobile robot.” Proceedings 2011 International Conference on System Science and Engineering (2011): 223-228.
[12]. Kowalczyk, Wojciech. (2019). Rapid Navigation Function Control for Two-Wheeled Mobile Robots. Journal of Intelligent & Robotic Systems. 93. 10.1007/s10846-018-0879-4.

Kinematic Model of Unicycle-Like Mobile Robot

The kinematic model of the mobile robot is written as:



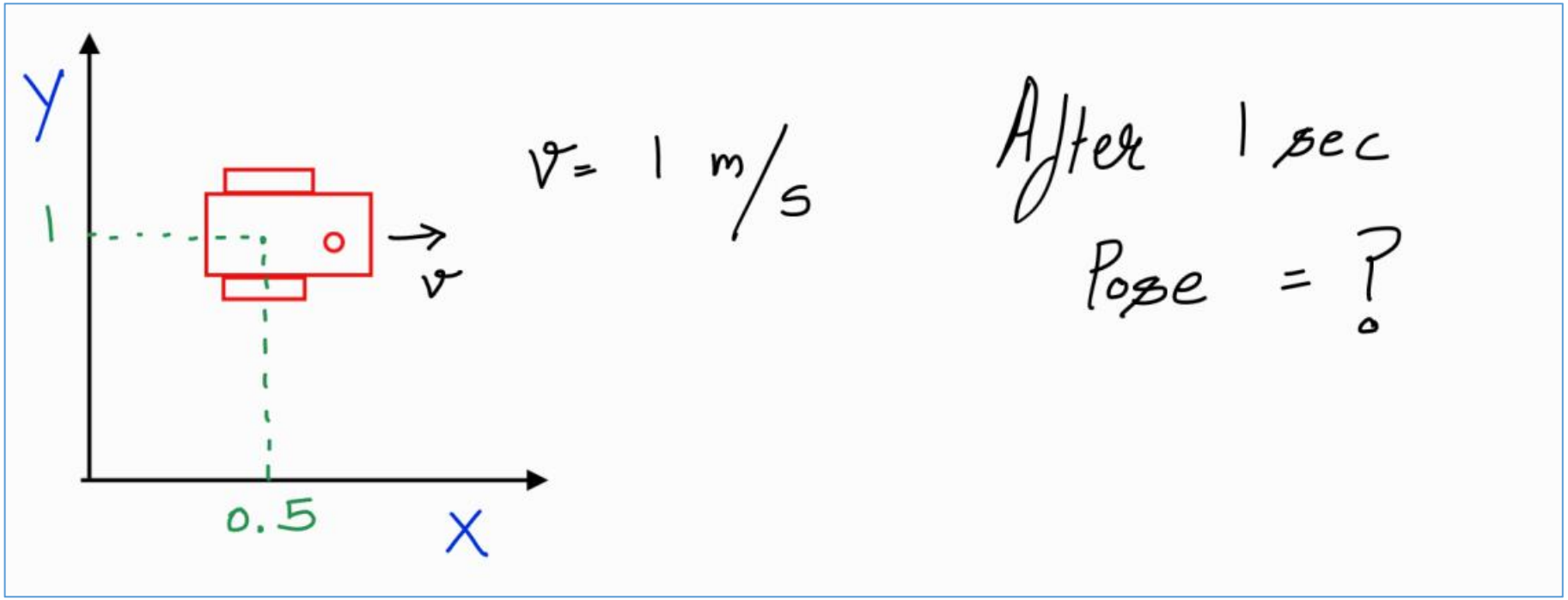
$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 \\ \sin\theta & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v \\ \omega \end{bmatrix},$$

The robot pose is represented by vector $[x \quad y \quad \theta]^\top$. x, y, θ are the variables representing the pose of the robot in the global reference frame. The control vector is $[v \quad \omega]^\top$ where v and ω are linear and angular velocity controls of the robot respectively.

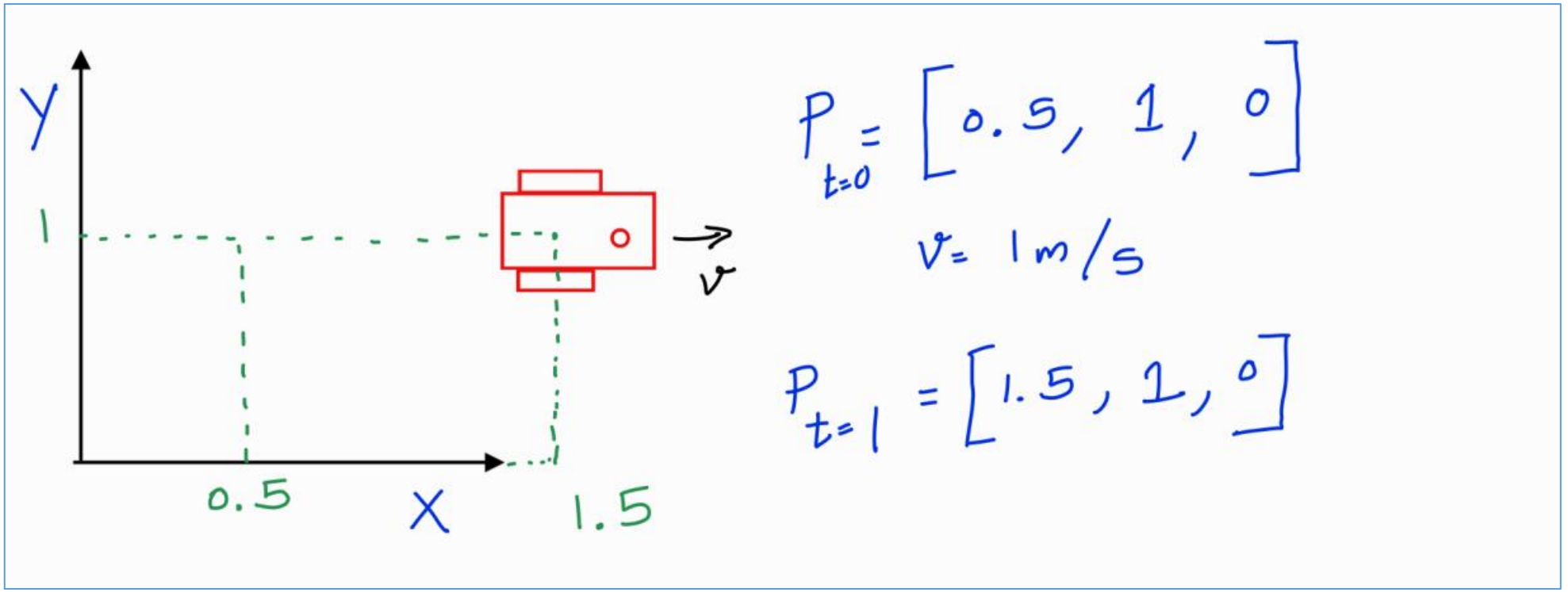
Linear velocity

Linear velocity, v , is defined as the rate of change of linear displacement, s, with respect to time, t, and for motion in a straight line:

$$v = \frac{s}{t}$$



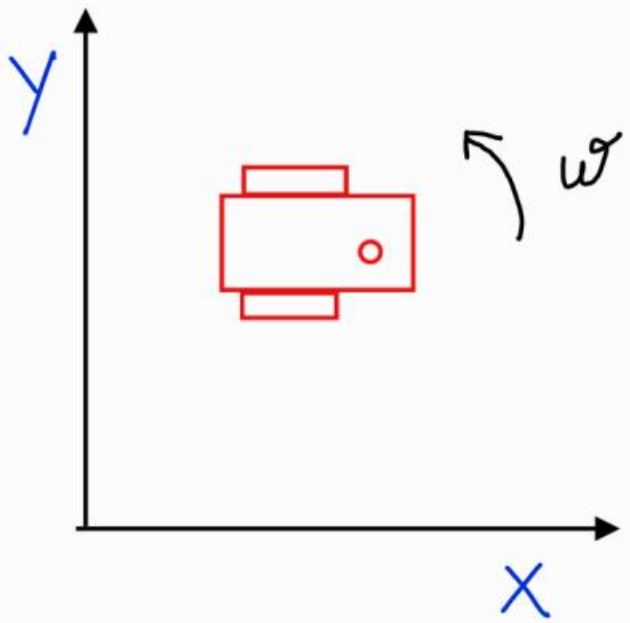
Linear velocity



Angular velocity

Angular velocity w is defined as the rate of change of angular displacement, θ, with respect to time, t, :

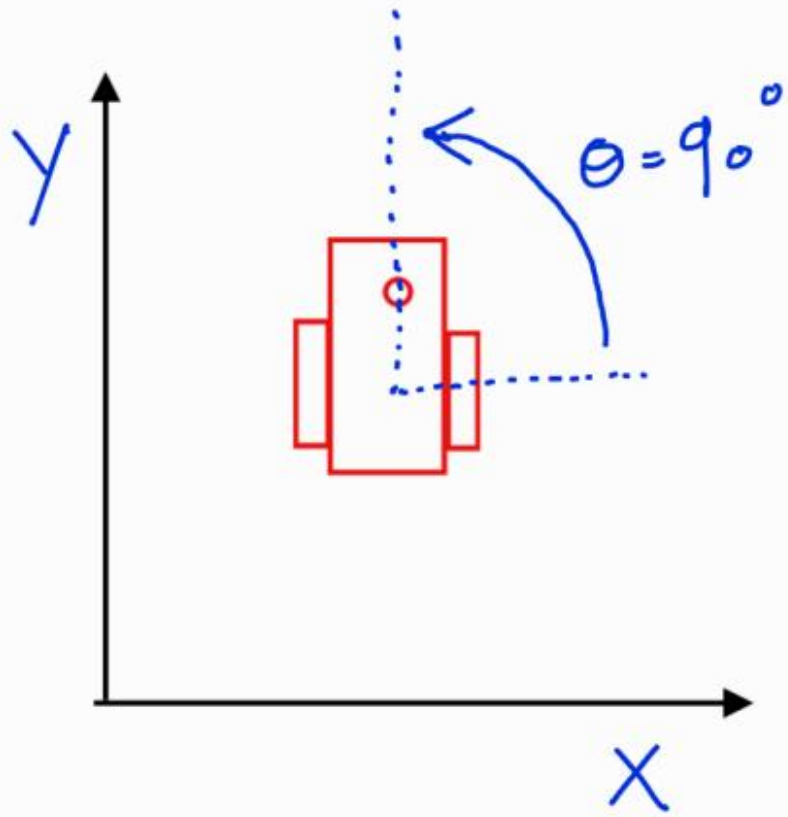
$$w = \frac{\theta}{t}$$



$\theta = 0$

$\omega = 1.57$ rad/s

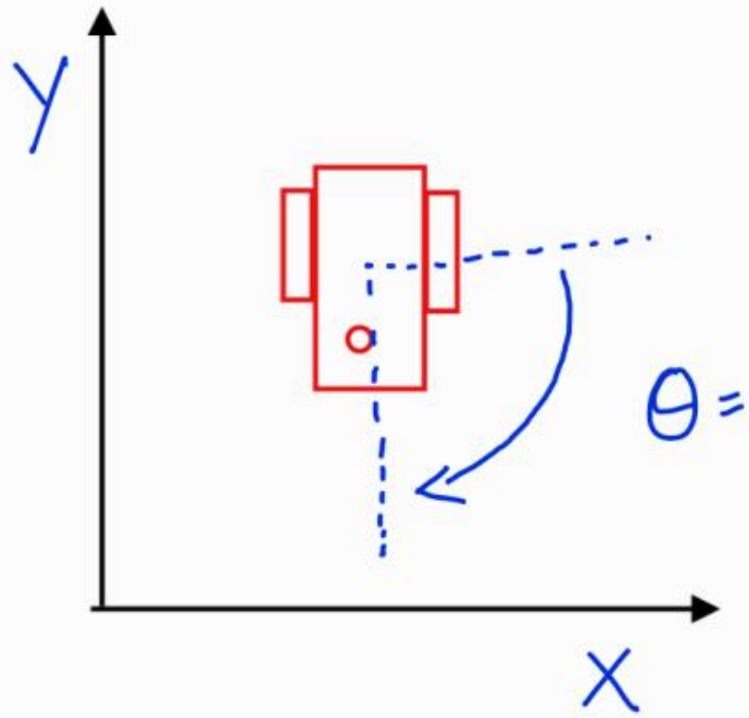
After 1 sec = ?



$$P_{t=0} = [0.5,\ 1,\ 0]$$

$$v = 0\ m/s\ ,\ w = 1.57$$

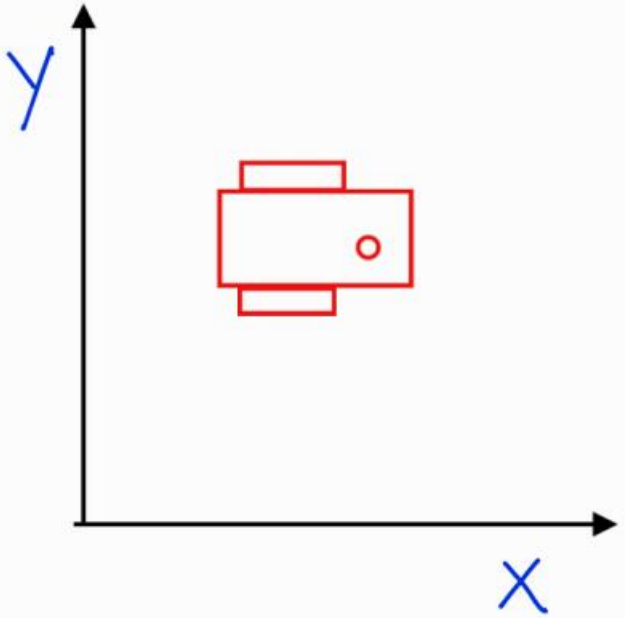
$$P_{t=1} = [0.5,\ 1,\ 1.57]$$



$$P_{t=0} = [0.5, 1, 0]$$

$$V = 0 \text{ m/s}, \quad W = -1.57$$

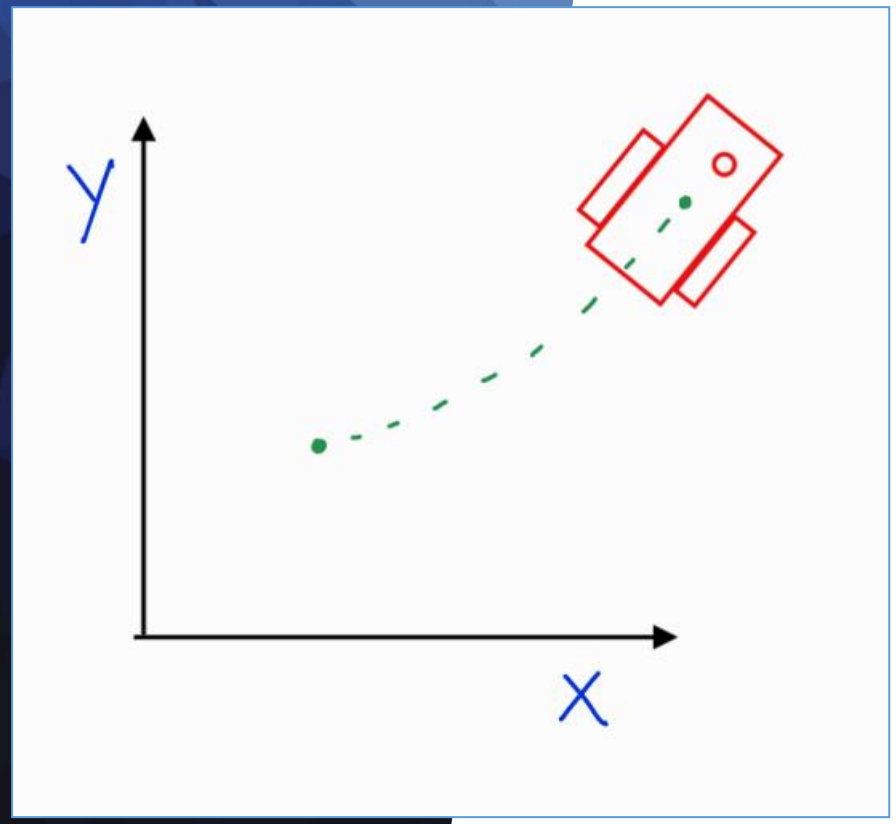
$$P_{t=1} = [0.5, 1, -1.57]$$



$v = 0.1\ m/s$

$w = 0.1\ m/s$

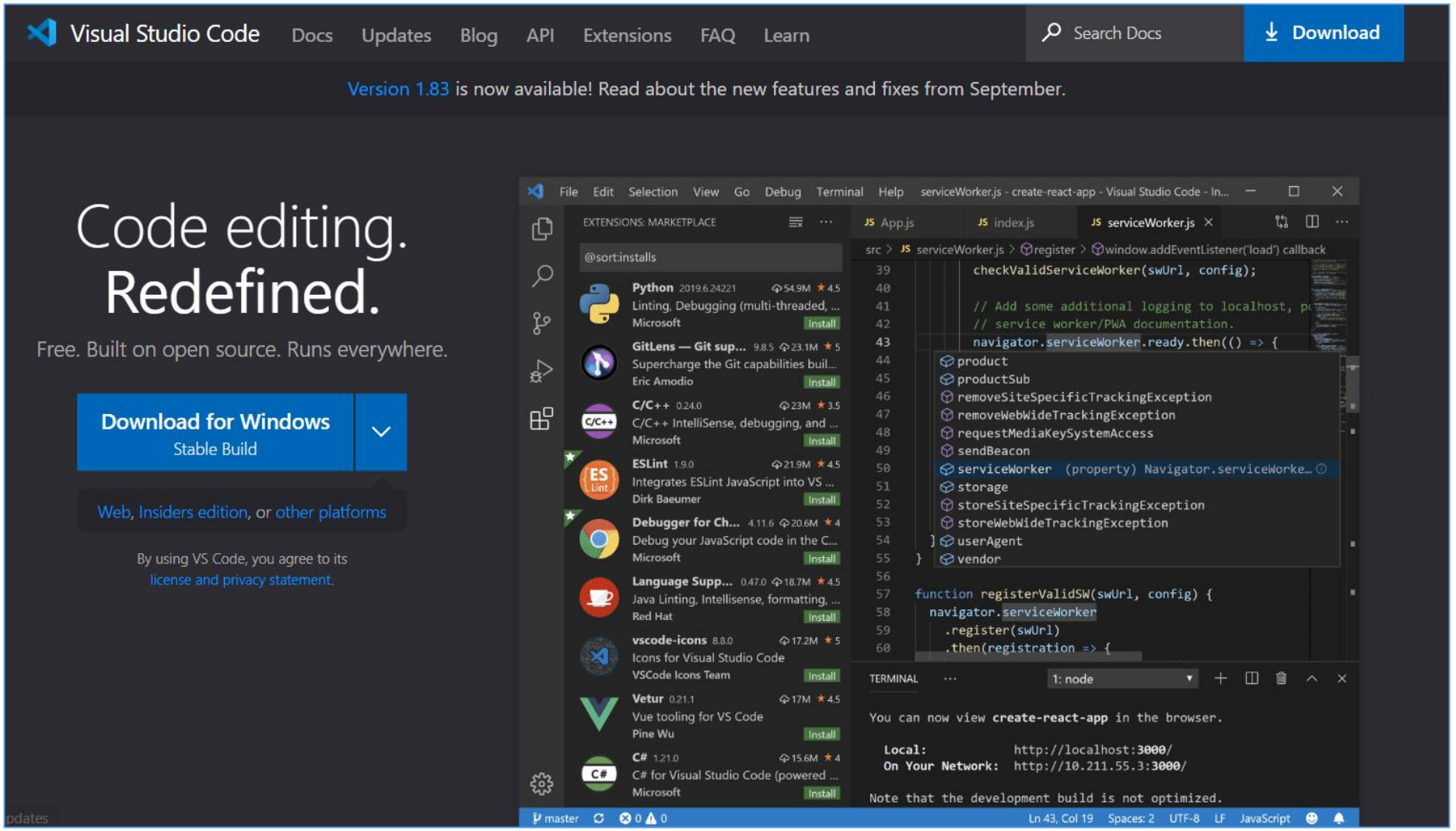
?



When the linear velocity and angular velocity will be given then the robot will form a curve or a circle.

PYTHON IDE

https://code.visualstudio.com/



How to write mathematical equations into codes?

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 \\ \sin\theta & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v \\ \omega \end{bmatrix},$$

```python
def update_pose(self, v, omega, dt):
    # Update the robot's pose based on linear velocity (v) and angular velocity (omega)
    self.x += v * np.cos(self.theta) * dt
    self.y += v * np.sin(self.theta) * dt
    self.theta += omega * dt

    return self.x,self.y,self.theta
```

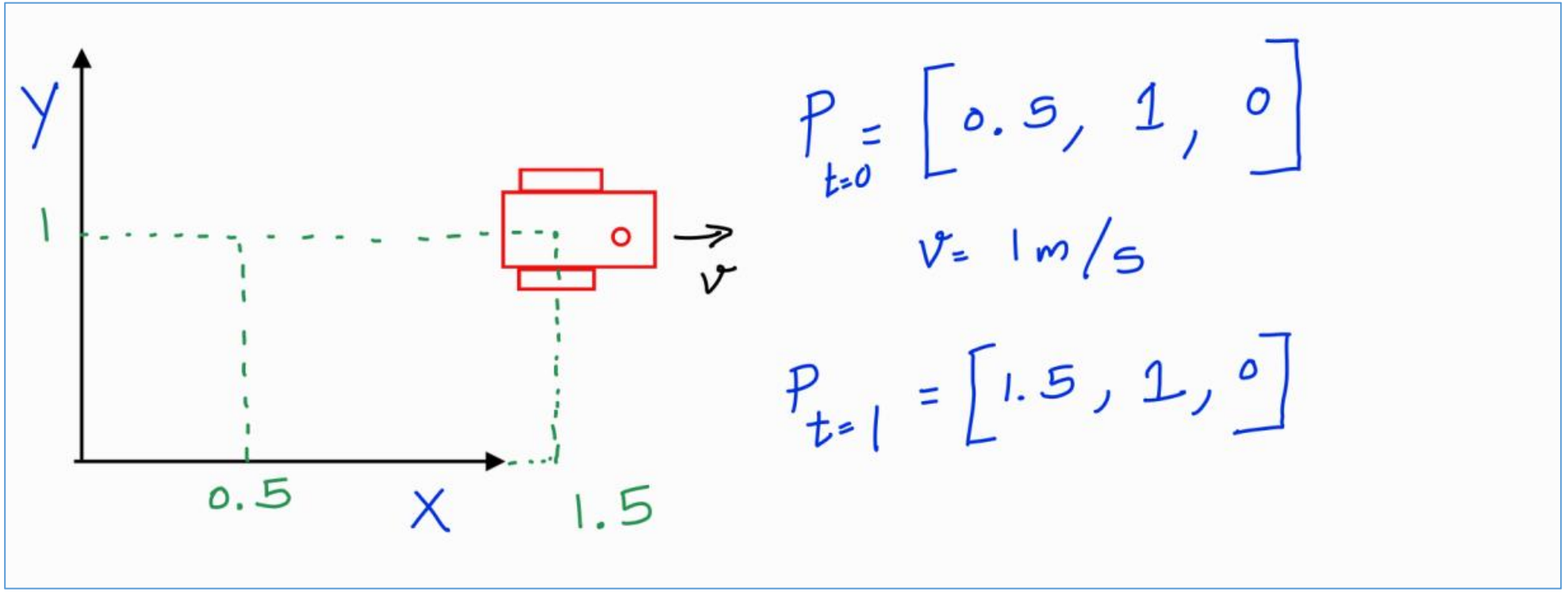
How to write mathematical equations into codes?

```python
import numpy as np

class UnicycleRobot:
    def __init__(self, x, y, theta):
        self.x = x  # Initial X position
        self.y = y  # Initial Y position
        self.theta = theta  # Initial orientation (angle)

    def update_pose(self, v, omega, dt):
        # Update the robot's pose based on linear velocity (v) and angular velocity (omega)
        self.x += v * np.cos(self.theta) * dt
        self.y += v * np.sin(self.theta) * dt
        self.theta += omega * dt

        return self.x,self.y,self.theta

```

How to write mathematical equations into codes?

```
17    init_x = 0.5
18    init_y = 1
19    init_theta = 0
20
21    print("Initial Pose :",init_x,init_y,init_theta)
22
23    Robot_1 = UnicycleRobot(init_x, init_y, init_theta)
24
25    v = 0 # m/s
26    omega = 1.52 # rad/sec
27    dt = 1 # sec
28    x,y,theta = Robot_1.update_pose(v, omega, dt)
29
30    print("Pose :",x,y,theta)
```

How to write mathematical equations into codes?




```
Initial Pose : 0.5 1 0
Pose : 0.5 1.0 1.52
PS C:\Users\ARPIT JOON>
```

Lets Introduce Plots to the Codes...

```python
import numpy as np
import matplotlib.pyplot as plt
import math

x_list = []
y_list = []
theta_list = []
time_list = []

class UnicycleRobot:
    def __init__(self, x, y, theta):
        self.x = x  # Initial X position
        self.y = y  # Initial Y position
        self.theta = theta  # Initial orientation (angle)

    def update_pose(self, v, omega, dt):
        # Update the robot's pose based on linear velocity (v) and angular velocity (omega)
        self.x += v * np.cos(self.theta) * dt
        self.y += v * np.sin(self.theta) * dt
        self.theta += omega * dt

        if(self.theta>math.radians(360)):
            self.theta = 0

        return self.x,self.y,self.theta

```

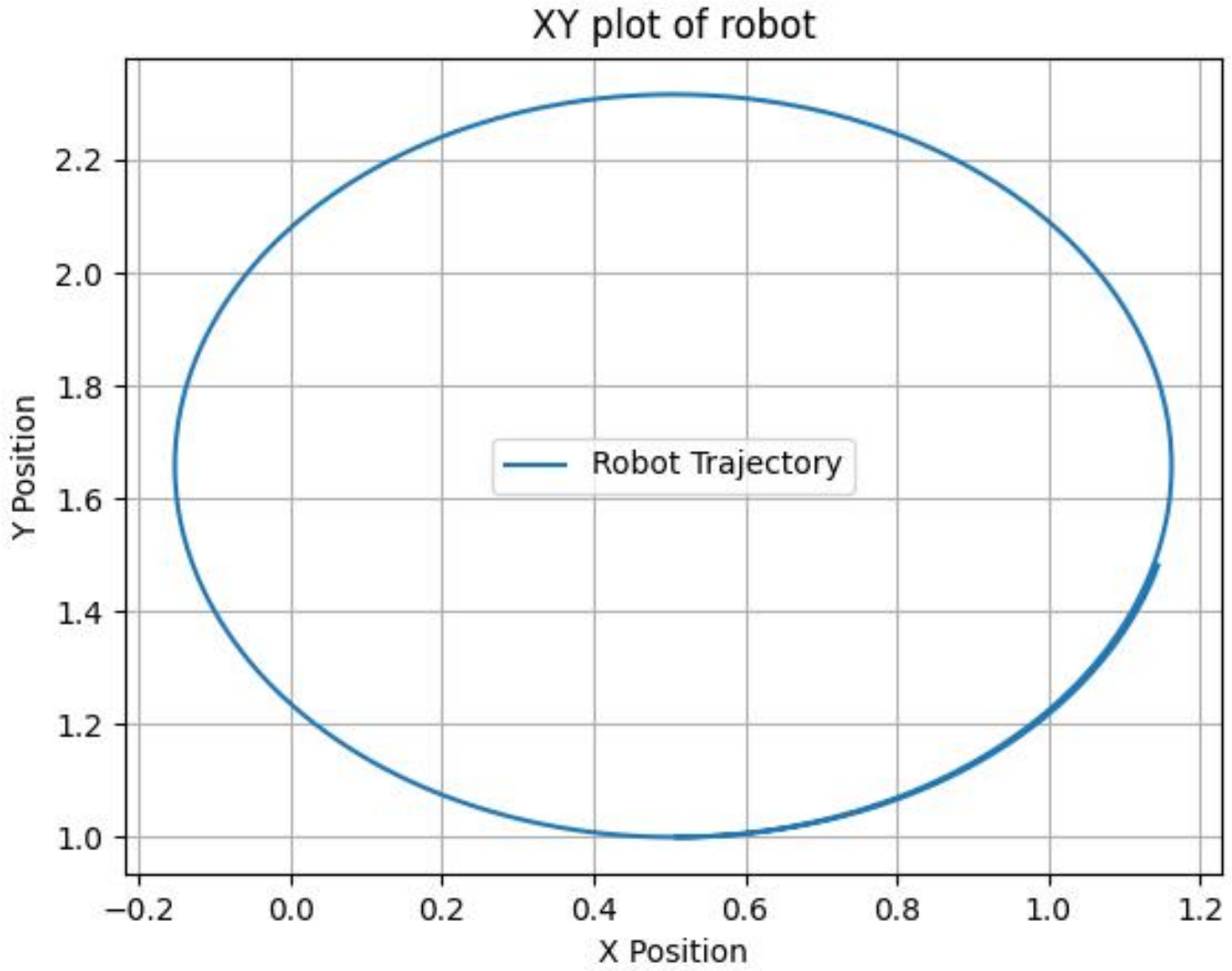
Lets Introduce Plots to the Codes...

```
26
27  init_x = 0.5
28  init_y = 1
29  init_theta = 0
30  print("Initial Pose :",init_x,init_y,init_theta)
31
32  Robot_1 = UnicycleRobot(init_x, init_y, init_theta)
33
34  v = 0.1 # m/s
35  omega = 0.152 # rad/sec
36  dt = 0.1 # sec
37  time = 0
38  for x in range(500):
39      x,y,theta = Robot_1.update_pose(v, omega, dt)
40      time +=dt
41
42      x_list.append(x)
43      y_list.append(y)
44      theta_list.append(theta)
45      time_list.append(time)
46
```

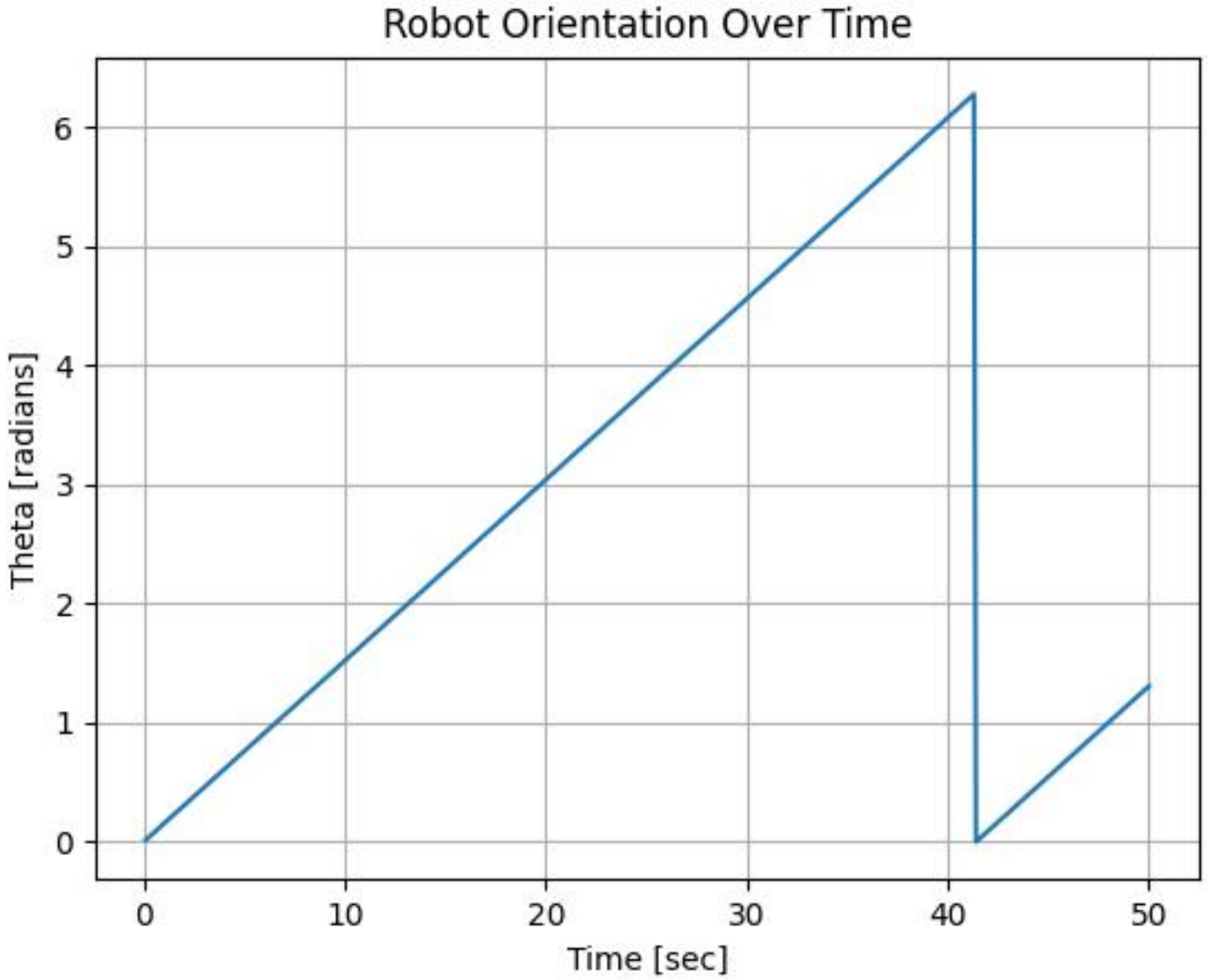
Lets Introduce Plots to the Codes…

```
46
47    plt.figure()
48    plt.plot(x_list, y_list, label="Robot Trajectory")
49    plt.xlabel("X Position")
50    plt.ylabel("Y Position")
51    plt.title("XY plot of robot")
52    plt.grid(True)
53    plt.legend()
54
55    plt.figure()
56    plt.plot(time_list, theta_list, label="Robot theta")
57    plt.xlabel("Time [sec]")
58    plt.ylabel("Theta [radians]")
59    plt.title("Robot Orientation Over Time")
60    plt.grid(True)
61
62    plt.show()
```

Lets Introduce Plots to the Codes...

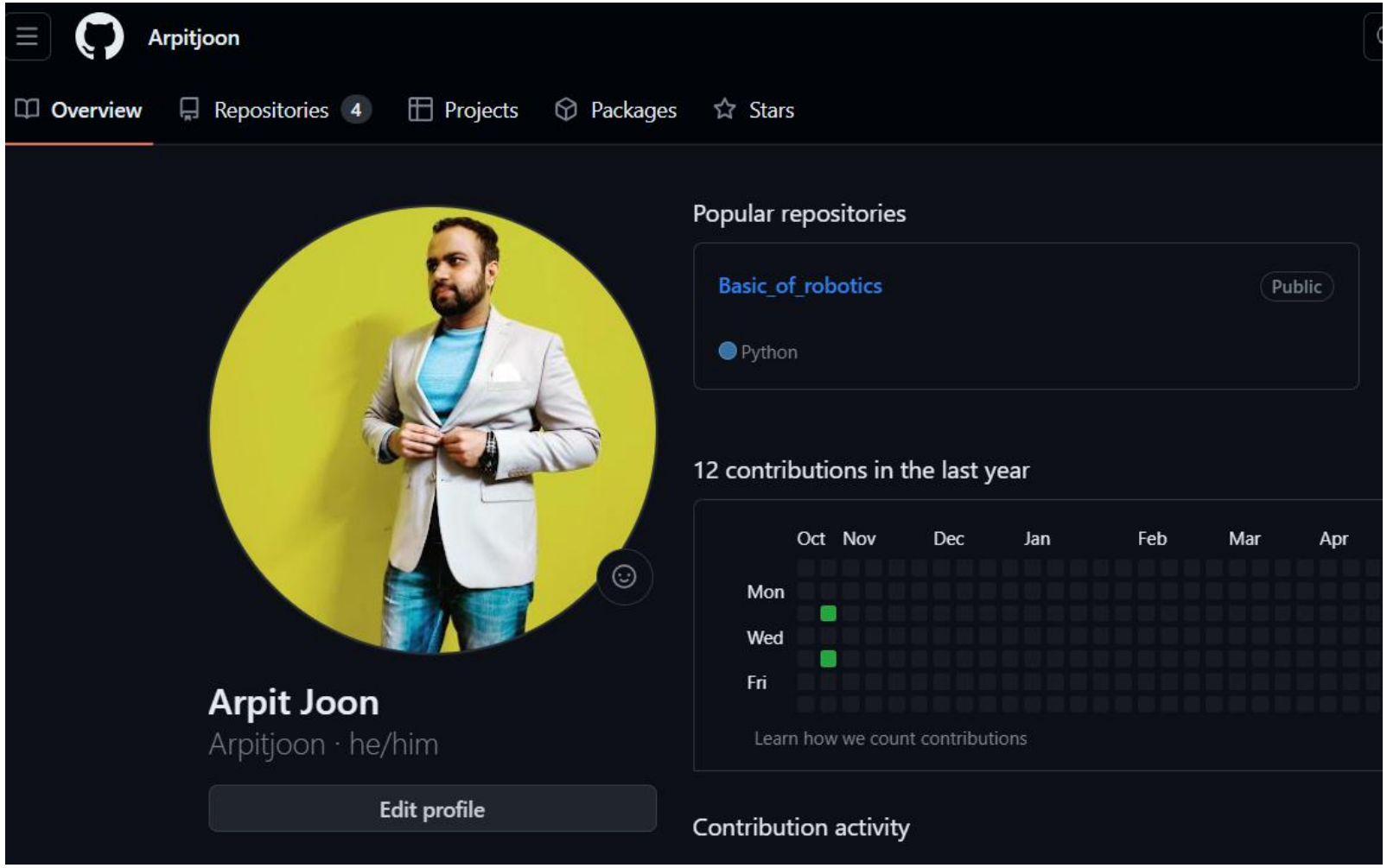


Lets Introduce Plots to the Codes...

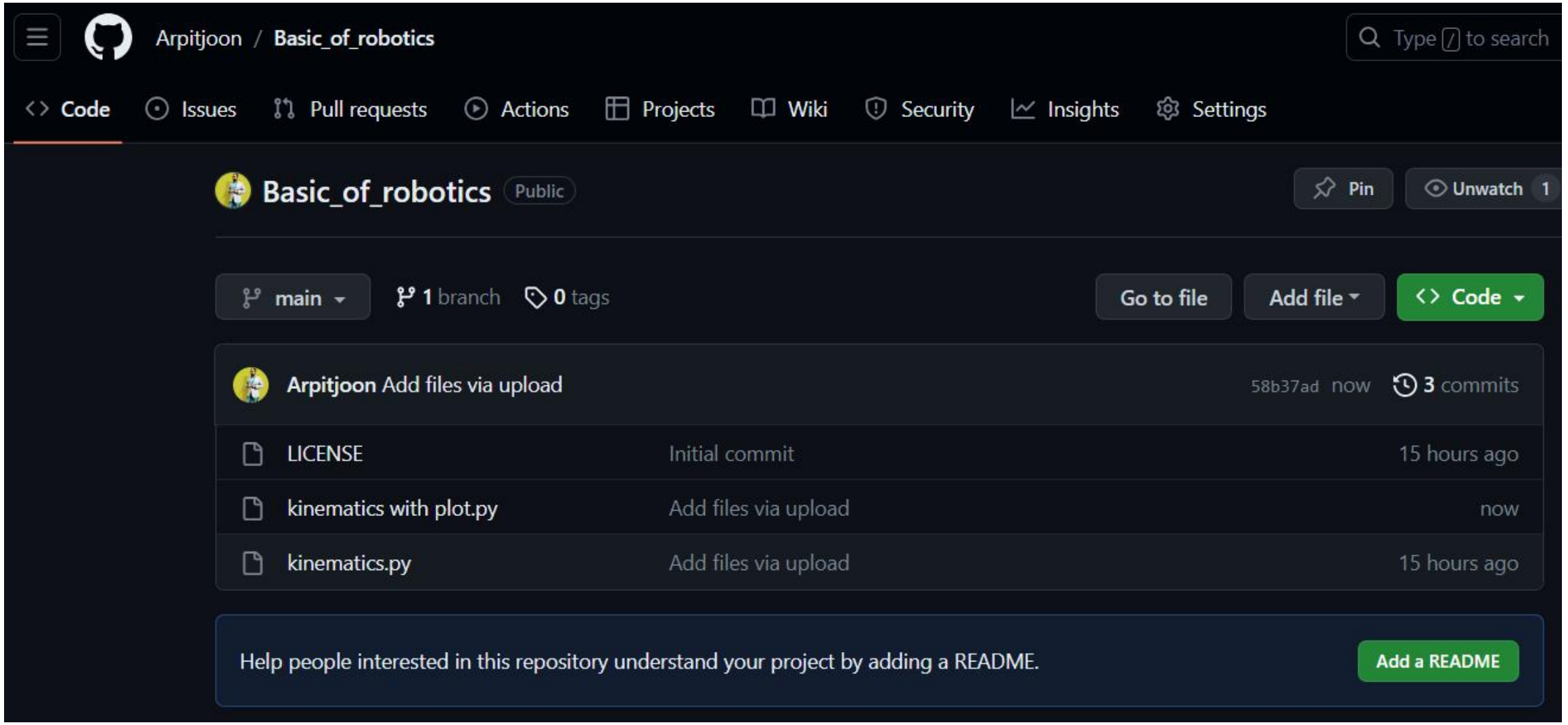


Download Codes from Github

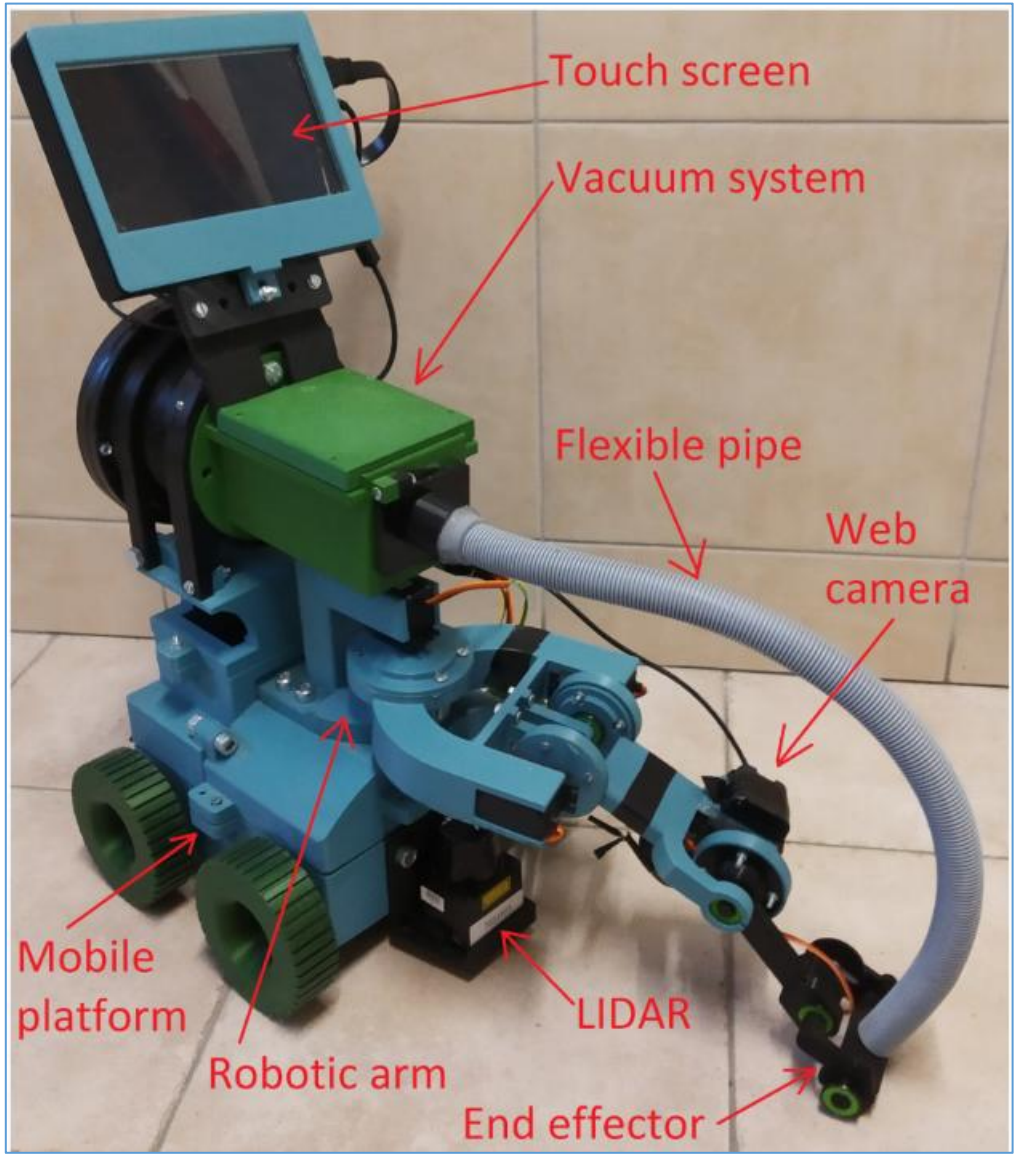
github.com/Arpitjoon



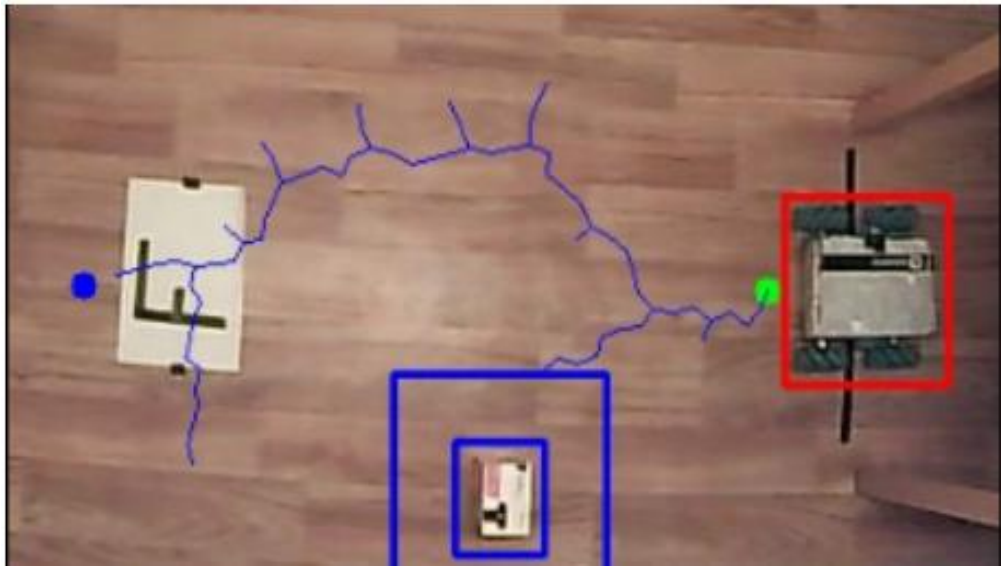
Download Codes from Github

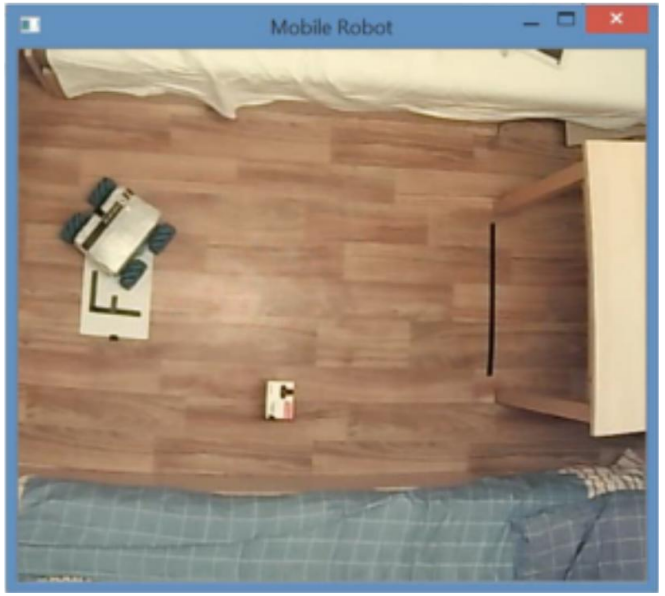


My Previous Projects



My Previous Projects





My Previous Projects

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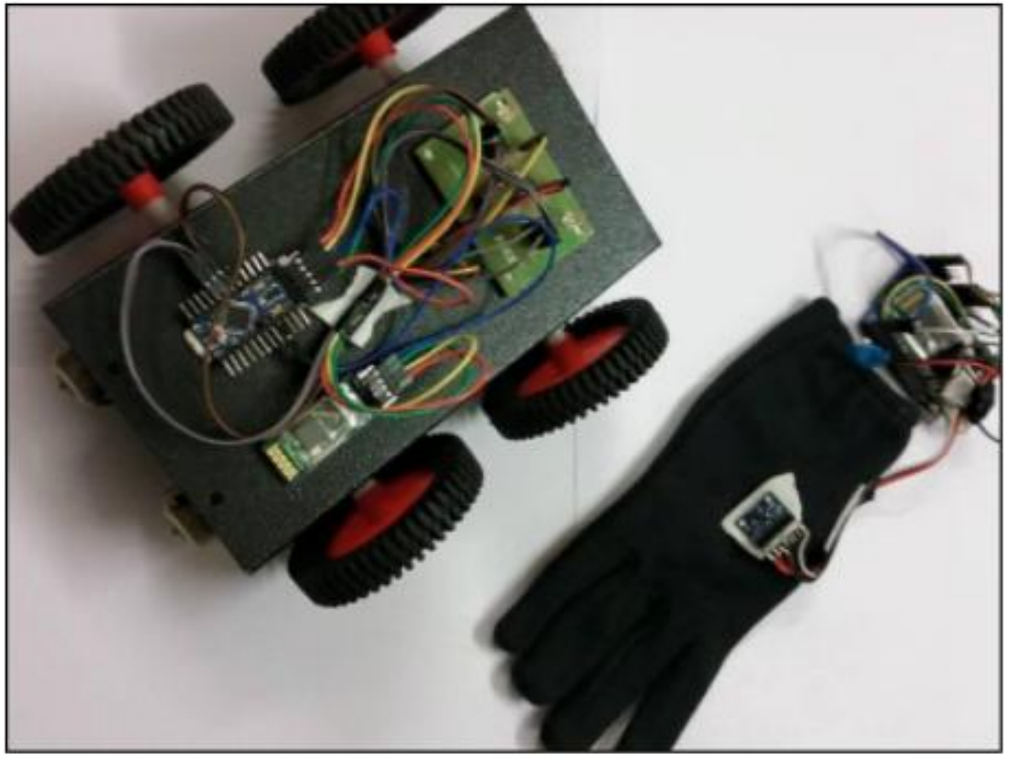
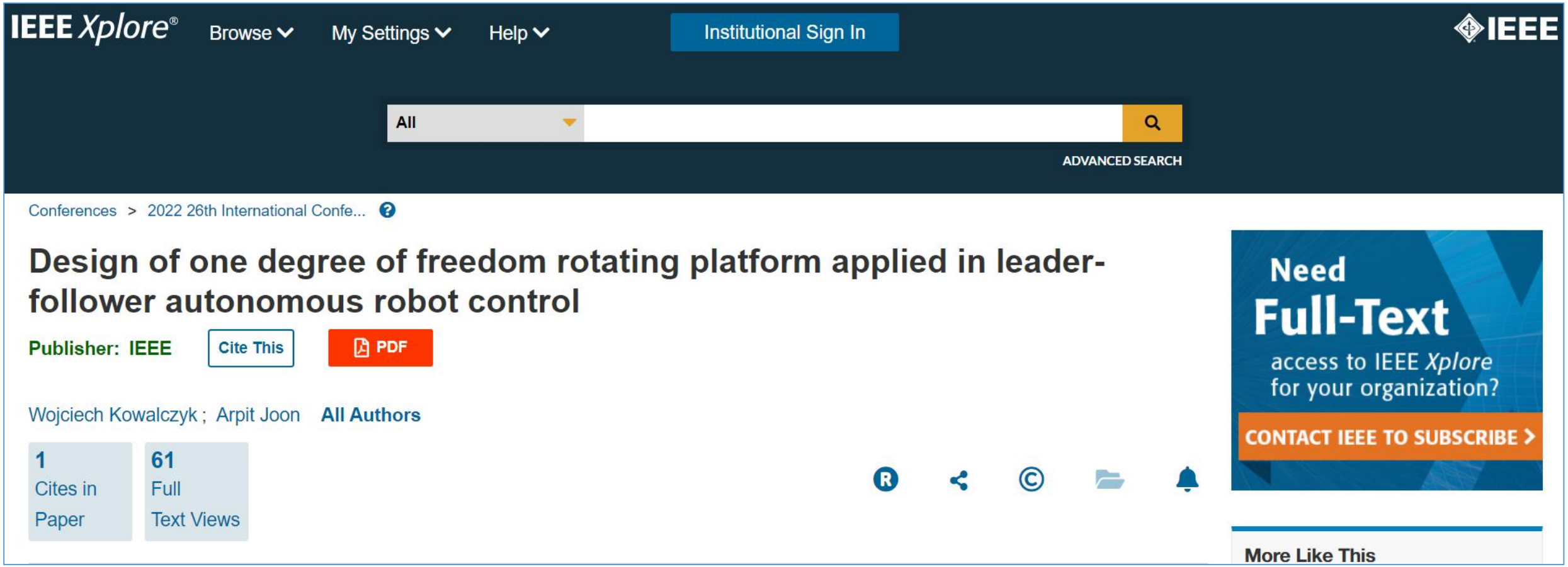
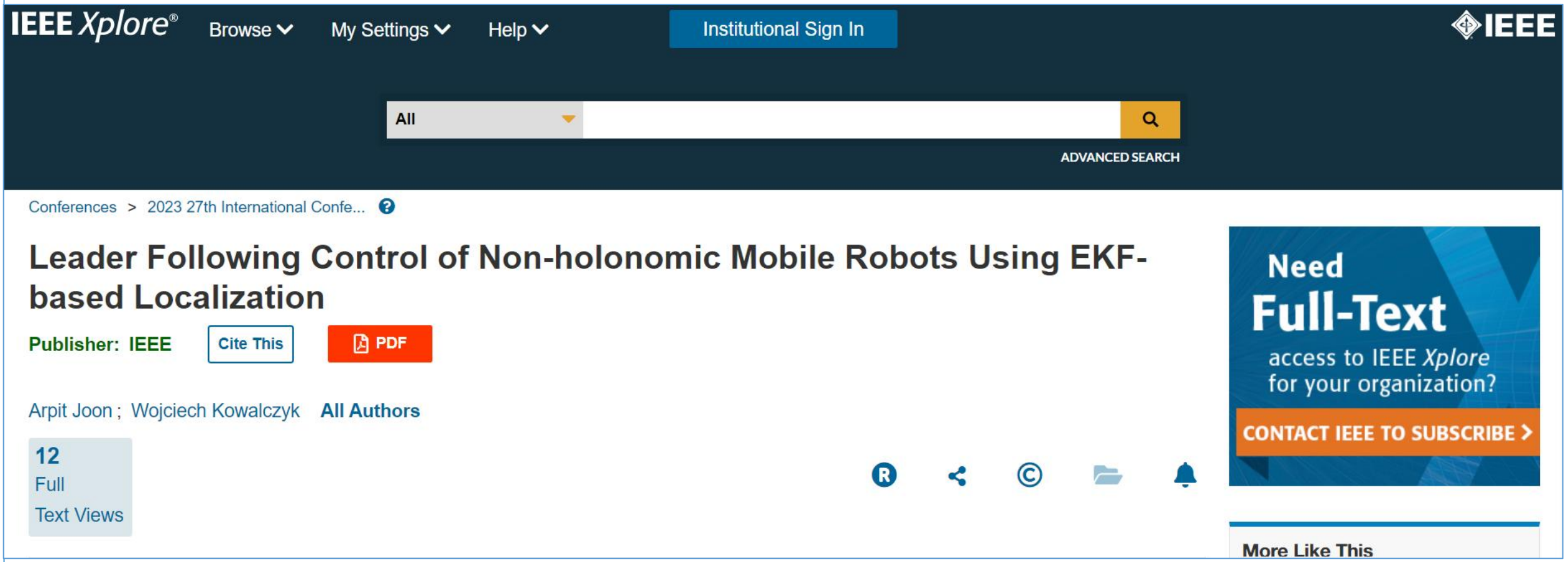


Research papers

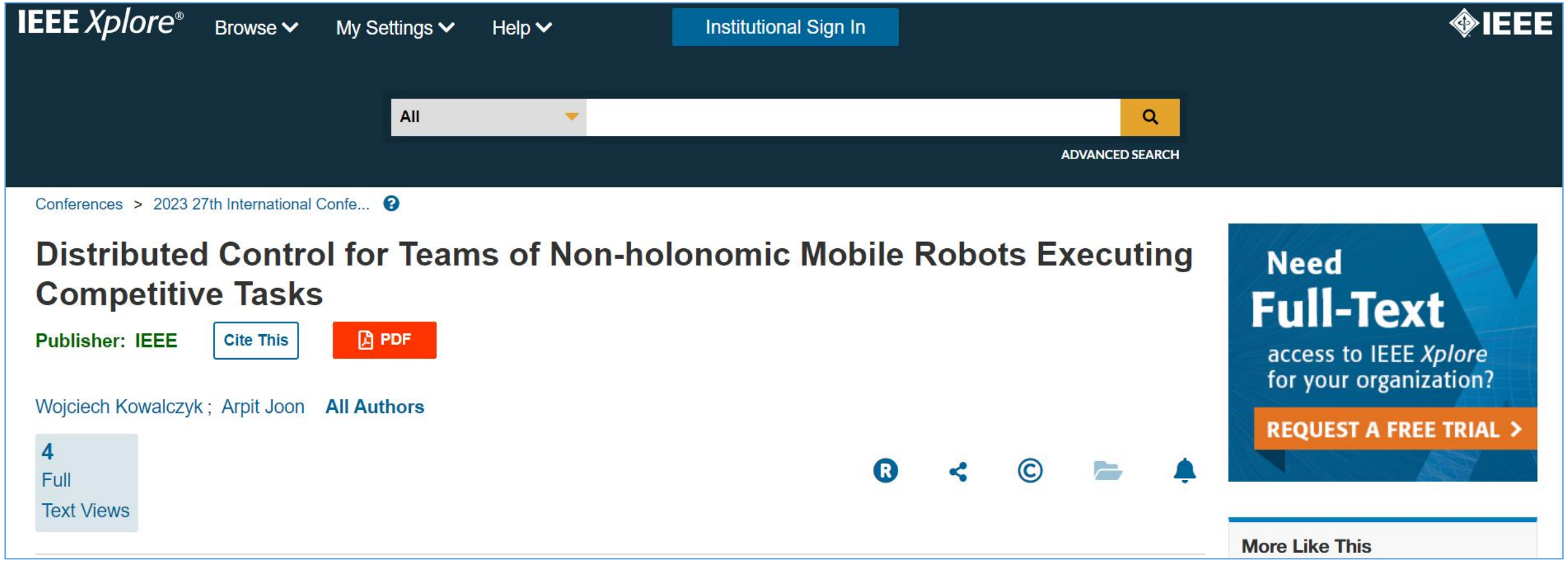
Research papers



Research papers



Research papers



Thanks

THANK YOU FOR LISTENING

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