TRASH

TANDEM ROVER & AERIAL SCRAP HARVESTER

The Tandem Rover and Aerial Scrap Harvester System

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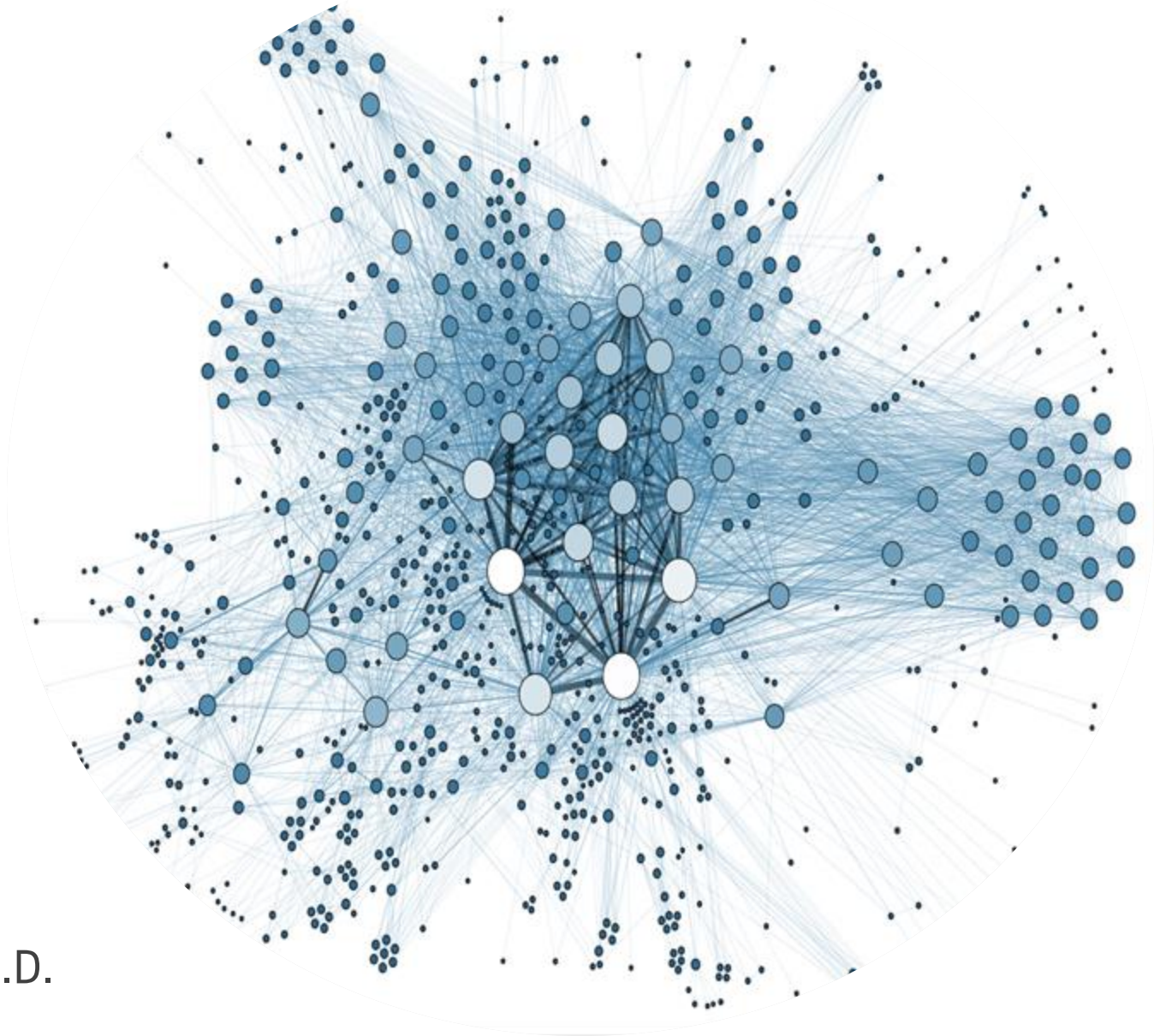


- With thanks to our advisor, Waleed Meleis, Ph.D.
- Special thanks to Taskin Padir, Ph.D.

Need

Littering costs the U.S. **$11.5 billion** every year.

This **does not include** indirect costs, including: decreases in property values, reduced commerce and tourism, and environmental and health hazards.

Accumulating litter can lead to arsenic and formaldehyde in our waterways, microplastic contamination, sewage pipes malfunctioning, wildlife death, and disease outbreaks.

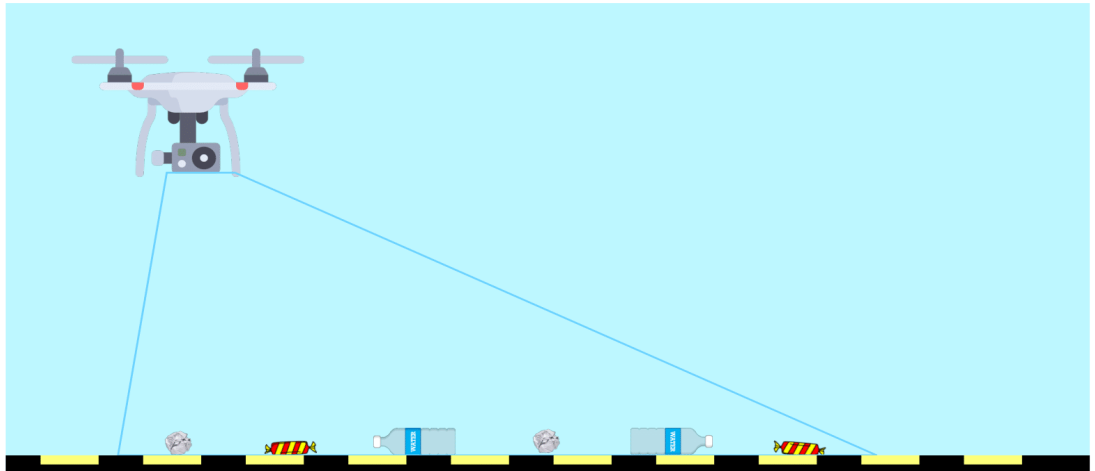
60% of all water pollution is attributable to litter.

Approach

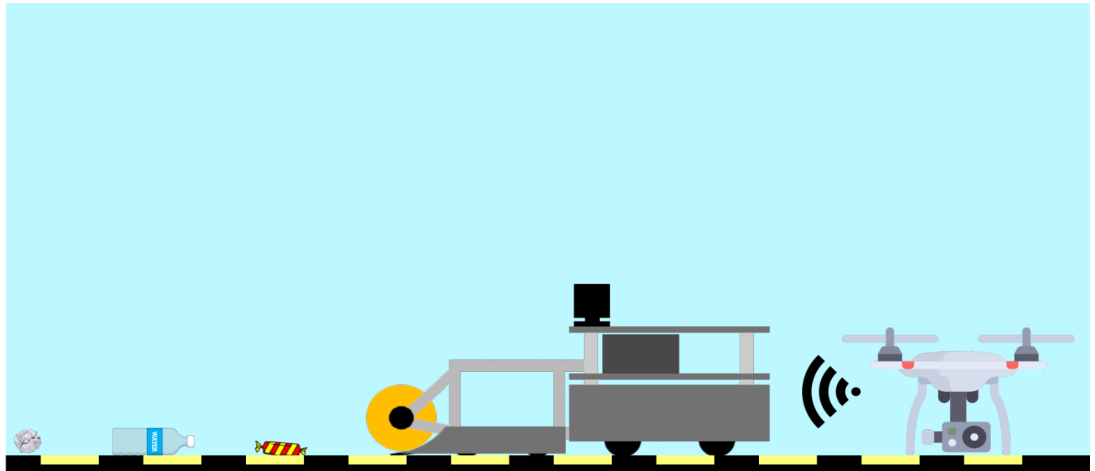
Cleaning and clearing common roadside litter using robotics (cigarette butts, plastic water bottles, fast food wrappers, glass and aluminum alcohol containers, etc.)

The Tandem Rover and Aerial Scrap Harvester uses automated **cooperation between a UAV** (drone) **and a UGV** (ground robot).

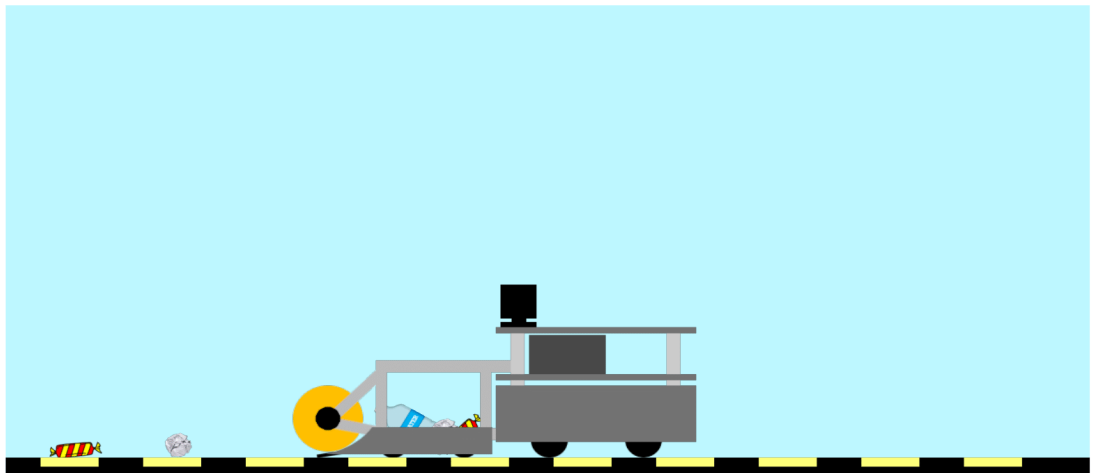
The UAV flies maps an set area to identify trash and debris. The UGV navigates that environment and collects the debris.



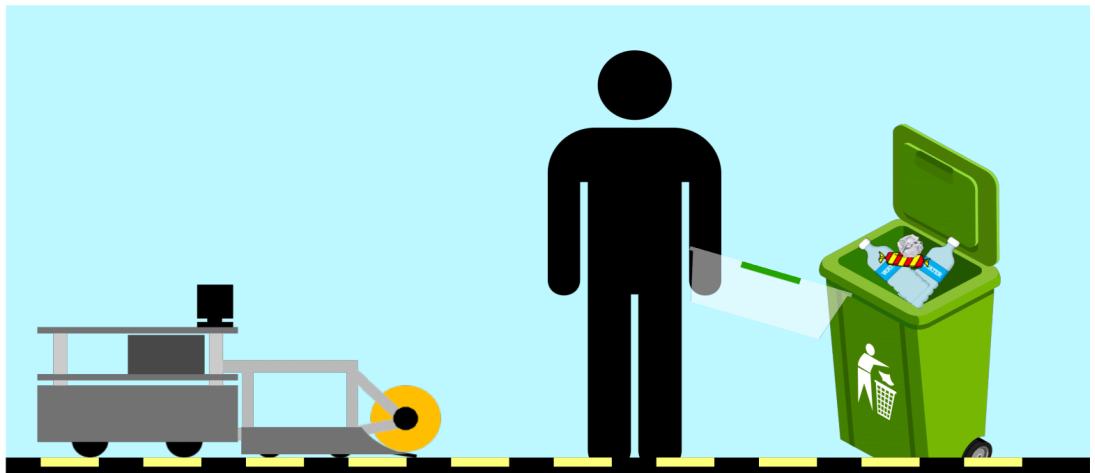
Step 1: UAV flies out to identify trash and map the surrounding area.



Step 2: UAV Lands and transfers map data to UGV over Wi-Fi.



Step 3: UGV takes most efficient path to pick up trash and clear area.



Step 4: Human operator removes storage bin and dumps trash into larger container.

Benefit

Cheaper and more effective than manual labor.

Manual collection is **often interrupted** by weather and worker availability since it **relies largely on volunteer efforts.**

Trash is left on ground for long stretches of time, leading to **degradation of litter** and **release of toxic microparticles** into environment.

Manual labor by nature must be periodic

T.R.A.S.H System can achieve **continuous, efficient collection** for lower **total cost.**

T.R.A.S.H **could significantly help the environment while saving taxpayer money.**

Other Robotic Attempts

- Minnesota Department of Transportation tried to implement a trash harvester
- They used a design similar to a snowplow machine
- Did not collect 100% percent of the paper, bottles and soda cans in its path.
- This machine also required a human operator, and it was very bulky making it impossible to navigate road-side and off-road terrains.
- It was ultimately never put into use and stayed a prototype

Robots

Turtlebot2 (UGV)

DJI Matrice 600 Pro (UAV)

TurtleBot2

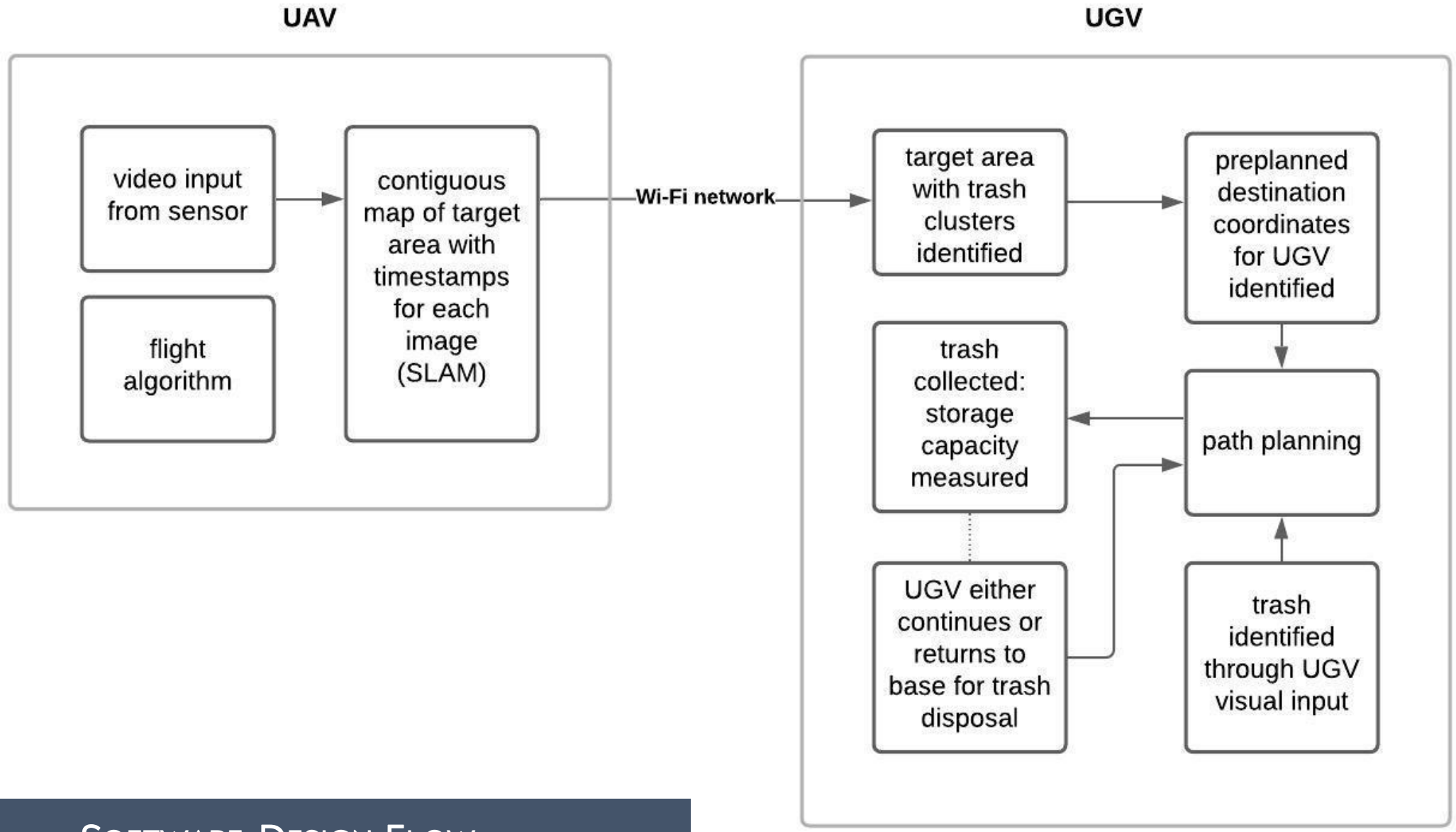
- Kobuki mobile base
- Ros Compatible Intel NUC
- Kinect Camera

DJI Matrice 600 Pro

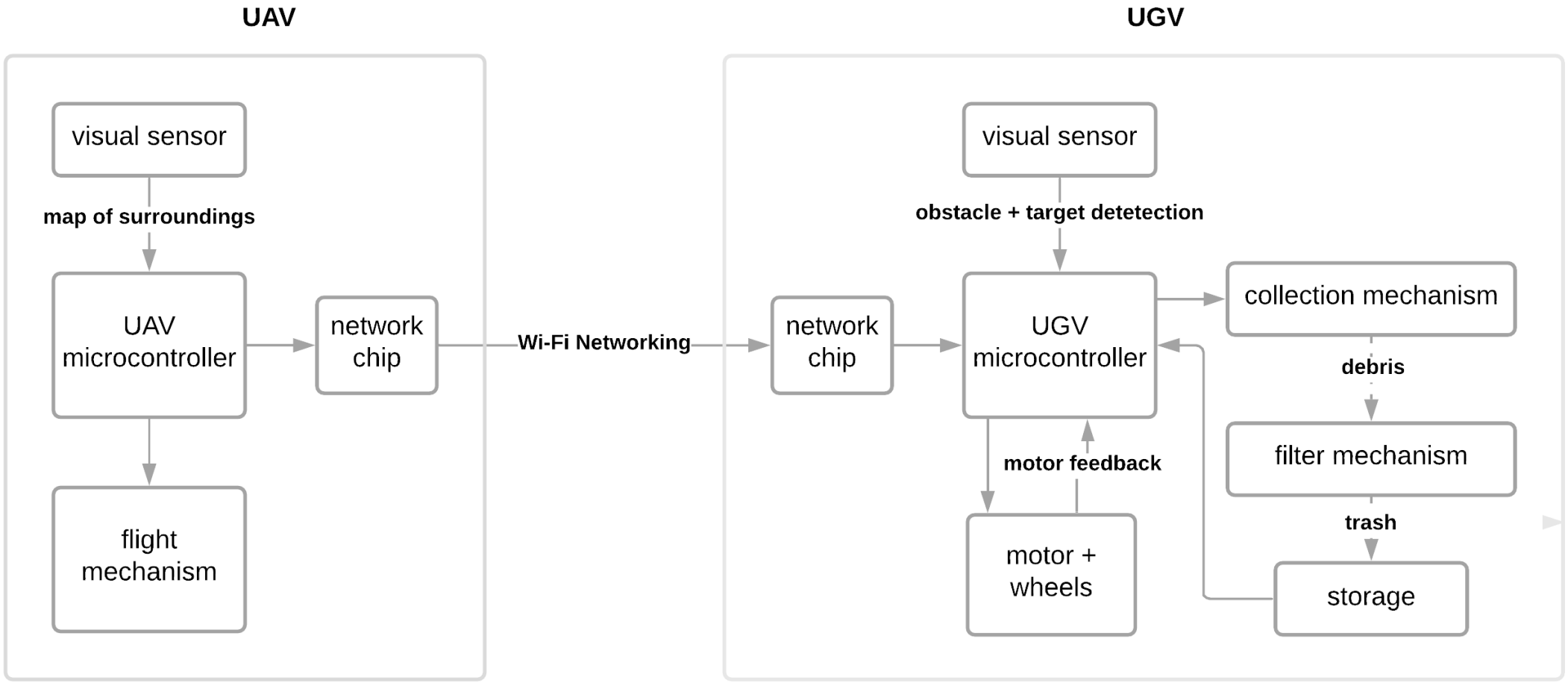
- Visual Sensor
- A3 Pro Flight Controller
- Wireless Transmission

Technical Specifications

- Our design limits the trash that the UGV can collect to:
  - Upper limit – average 600 ml water bottle that weighs **640g.**
  - Lower limit – standard cigarette butt, approximately **30-50mm in length.**
- Maximum trash load of **2kg.**
- Can **clear 250 sq feet in 10 minutes.**
- Will be able to complete approximately **5 trips** before requiring a manual operator to recharge the system.
- Planned testing environment is controlled stretch of pavement
- Specifications limited by the robots available to us.
- Assumes no rain and wind less than 8 meters per second



Software Design Flow



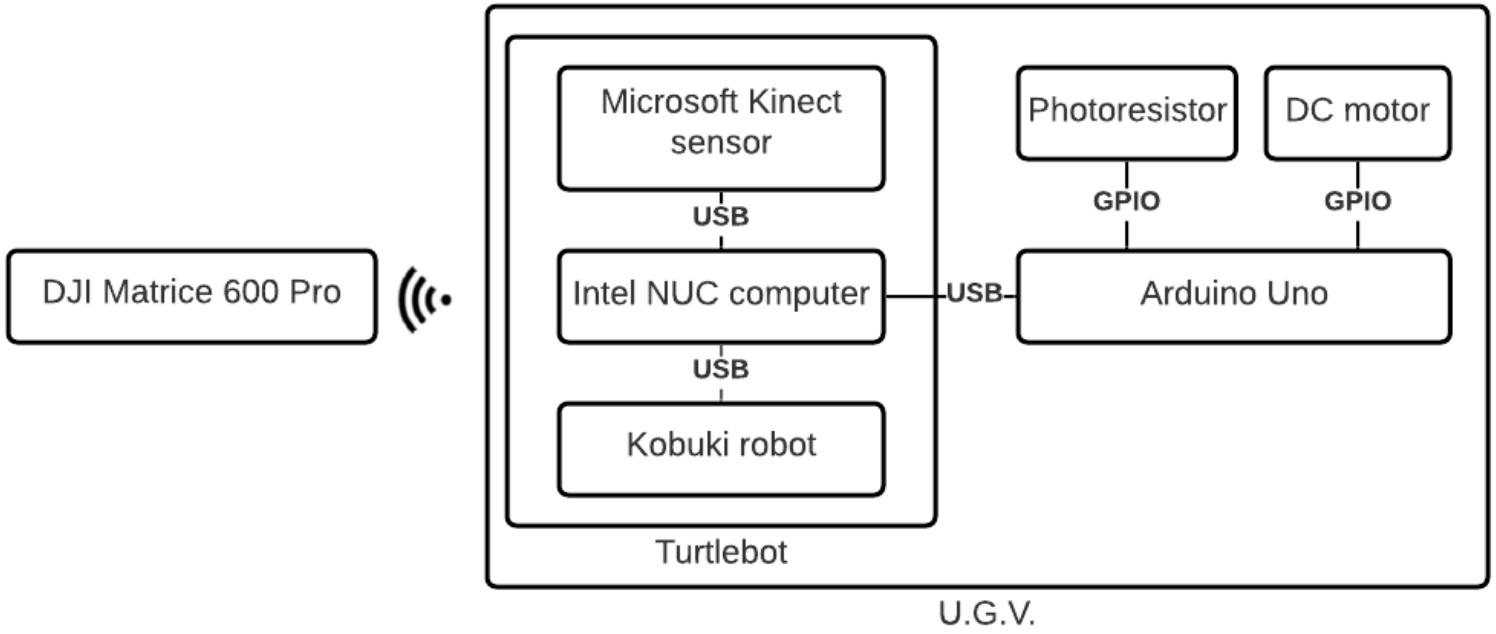
Hardware Design Flow

U.A.V.

- DJI Matrice 600 Pro comes **preprogrammed** with **flight algorithm**
- UAV's **visual sensor** will **create a map** of the area using **SLAM** (Simultaneous Localization and Mapping)
- Map will be relayed between the drone's **inbuilt network chip** and the microprocessor on the ground vehicle using a hotspot.

U.G.V.

- Analyzes UAV's map using **YOLO** to identify trash clusters
- Automatically generates most efficient path between trash clusters
- **Kinect sensor** performs **obstacle avoidance** and **ground-level trash identification**
- **Odometry wheels** of the Kobuki robot precisely navigate within the digital map
- Collects trash using a **rotary brush**
- **Monitors storage capacity** using **laser interrupt circuit** to determine when full load is achieved

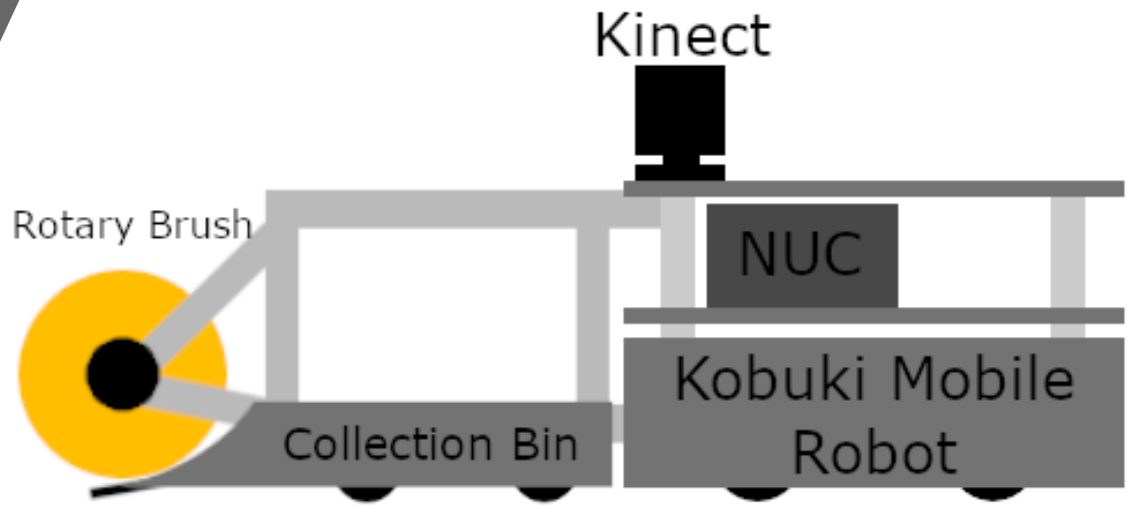


Mechatronics

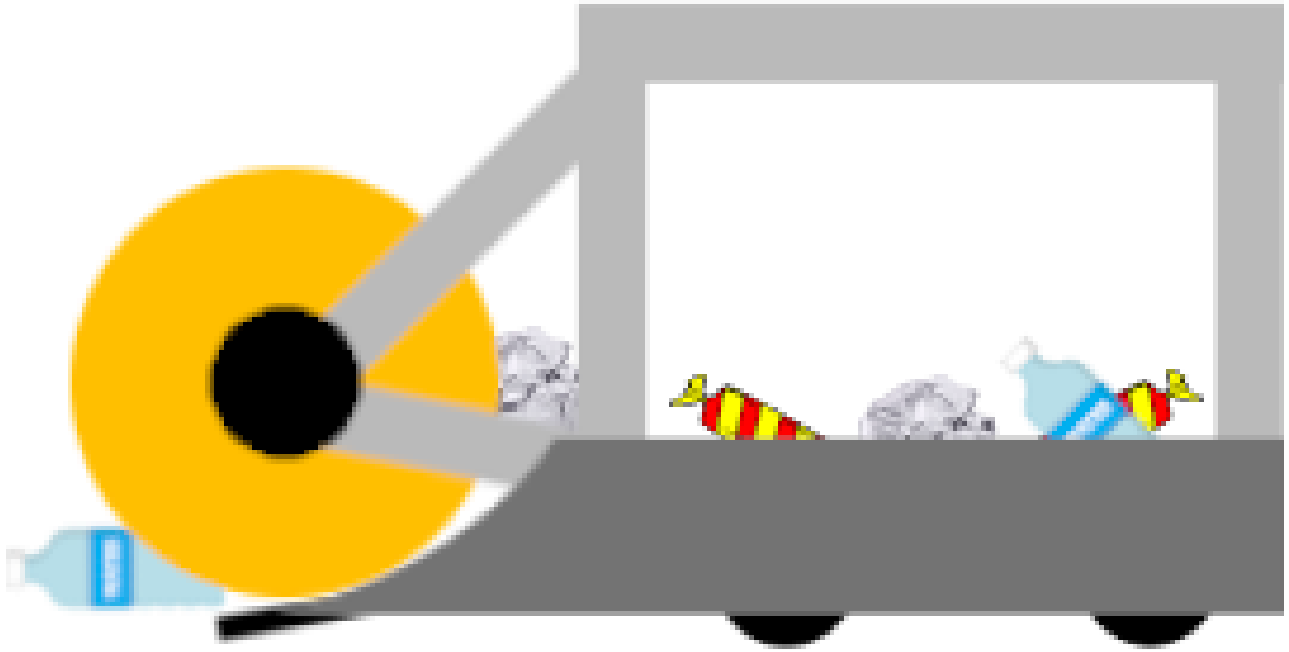
The collection mechanism will be fabricated in the machine shop and attached to the front of the TurtleBot2

When the U.G.V. determines it is in front of trash, it will turn on the rotary brush's motor and collect the trash

A sensor will be in the collection bin to determine whether there is room for more trash on the UGV



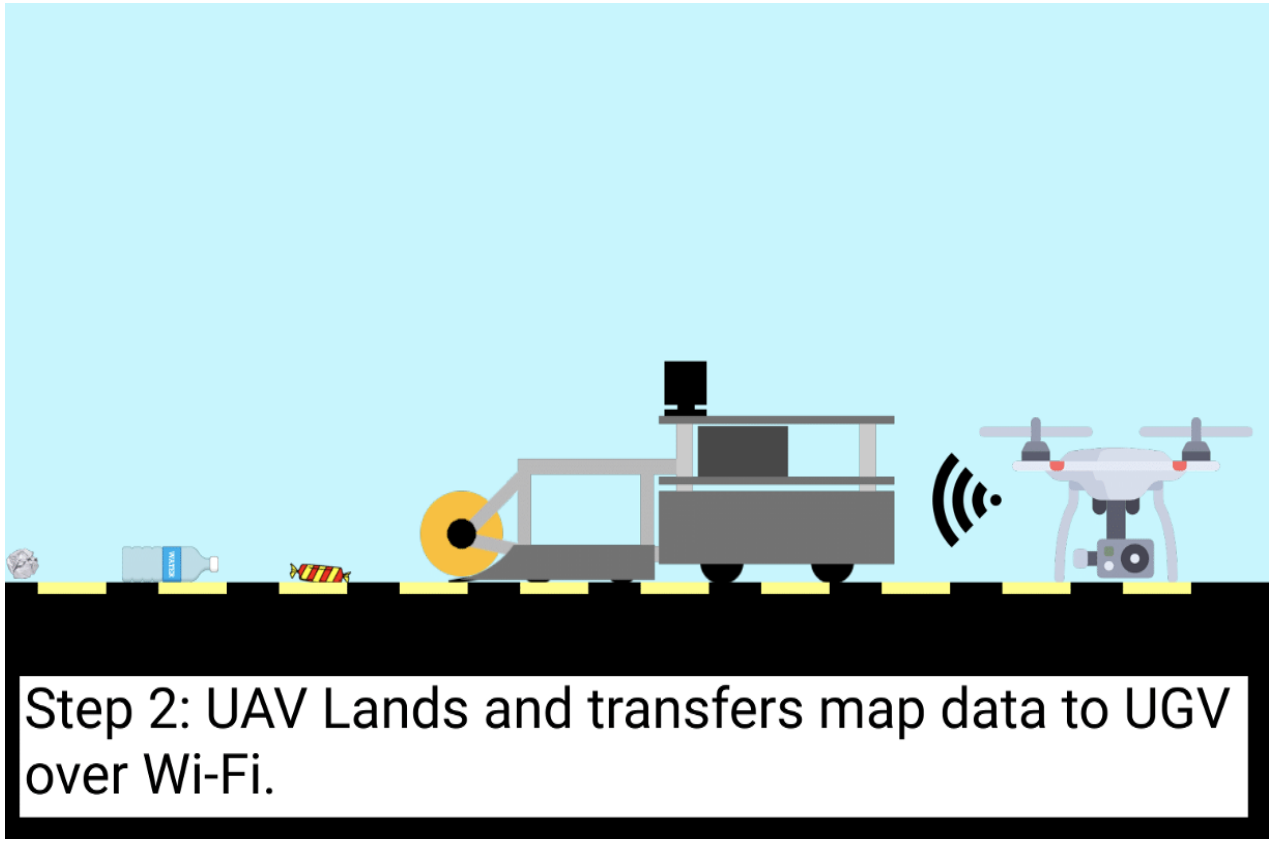
Collection Mechanism



- The frame will be built out of 80/20 aluminum bars, with sheet metal as a ramp and base.
- The rotary brush will be turned on when driving over trash to collect it.
- When the trash is in the collection bin, there is a filter for out of spec items to be discarded.

Networking

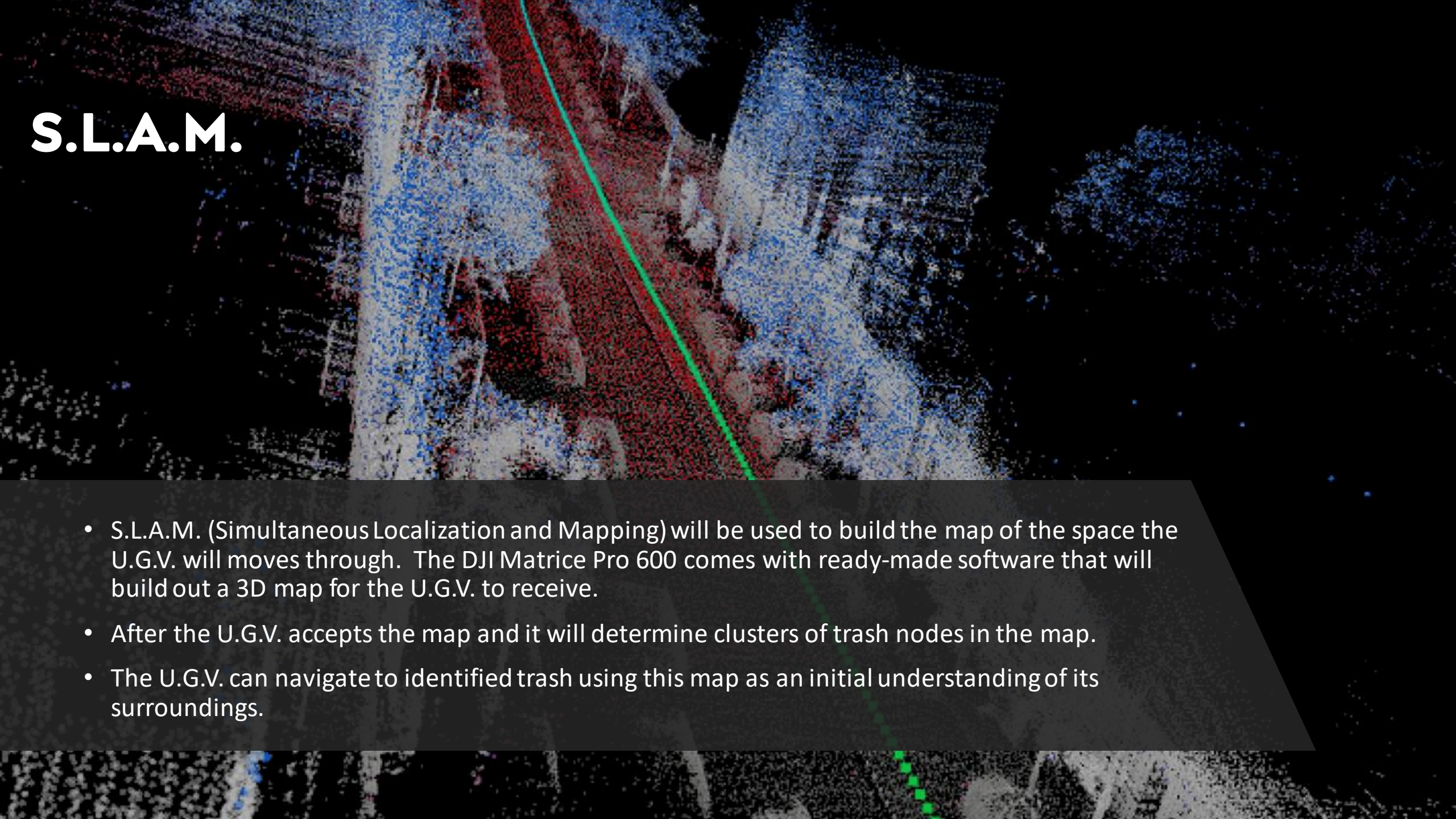
- Information will be relayed between the drone's **inbuilt network chip** and the NUC on the U.G.V. using a hotspot made with ***hostapd***.
- ROS topics will be the vehicle of data communication from the UAV to the UGV.
- The network protocol TCP/IP will be used as it is more reliable and has broader support within ROS's toolchain.



Computer Vision

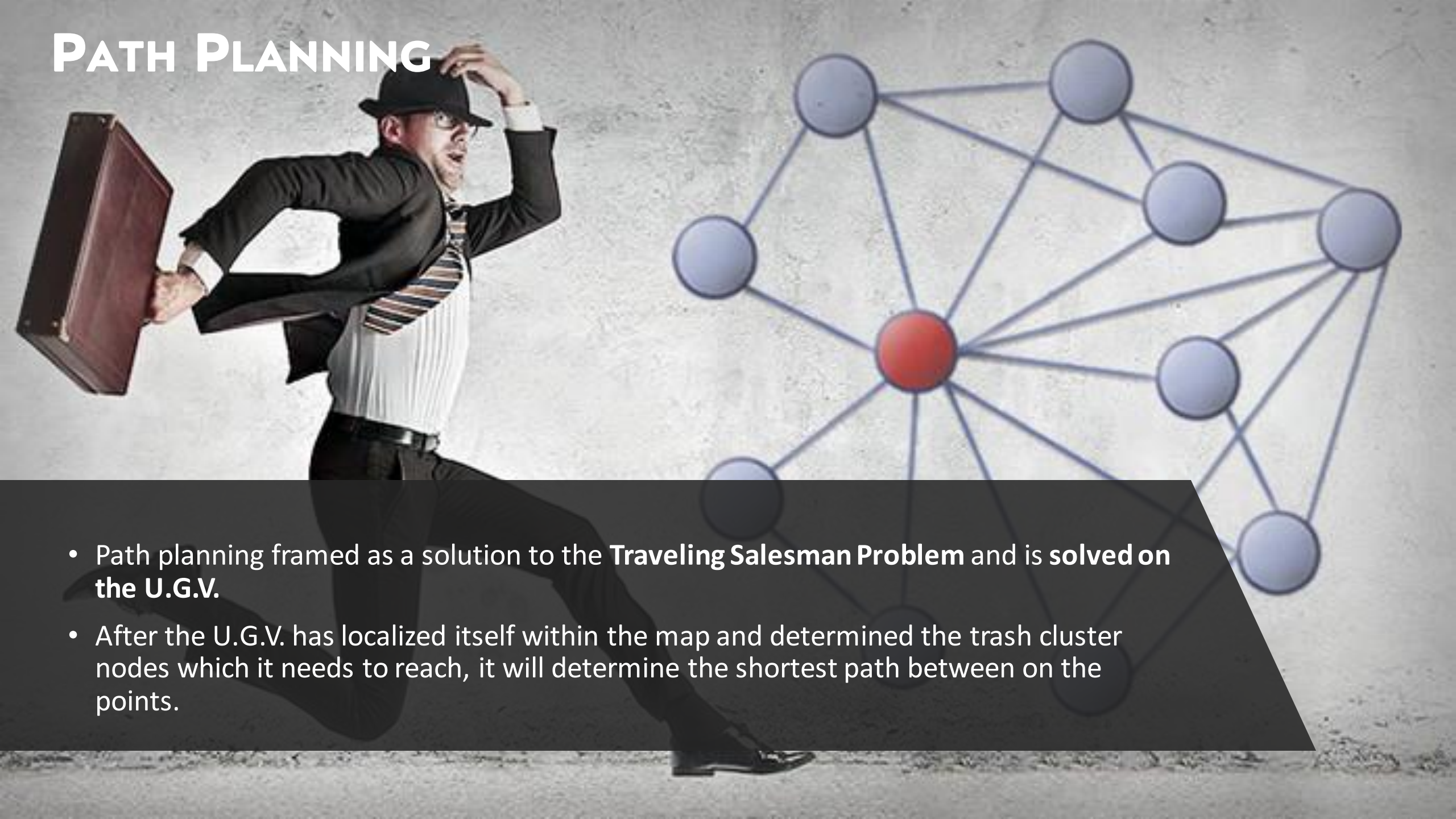
- Using You only Look Once (**Y.o.L.O.)** algorithm to identify any trash in images taken by the drone.
- **Y.o.L.O** provides **pre-trained CNN** that can be built upon with layers for identifying desired objects.
- Working with **open source dataset** for trash identification using **Y.oL.O**

S.L.A.M.



- S.L.A.M. (Simultaneous Localization and Mapping) will be used to build the map of the space the U.G.V. will moves through. The DJI Matrice Pro 600 comes with ready-made software that will build out a 3D map for the U.G.V. to receive.
- After the U.G.V. accepts the map and it will determine clusters of trash nodes in the map.
- The U.G.V. can navigate to identified trash using this map as an initial understanding of its surroundings.

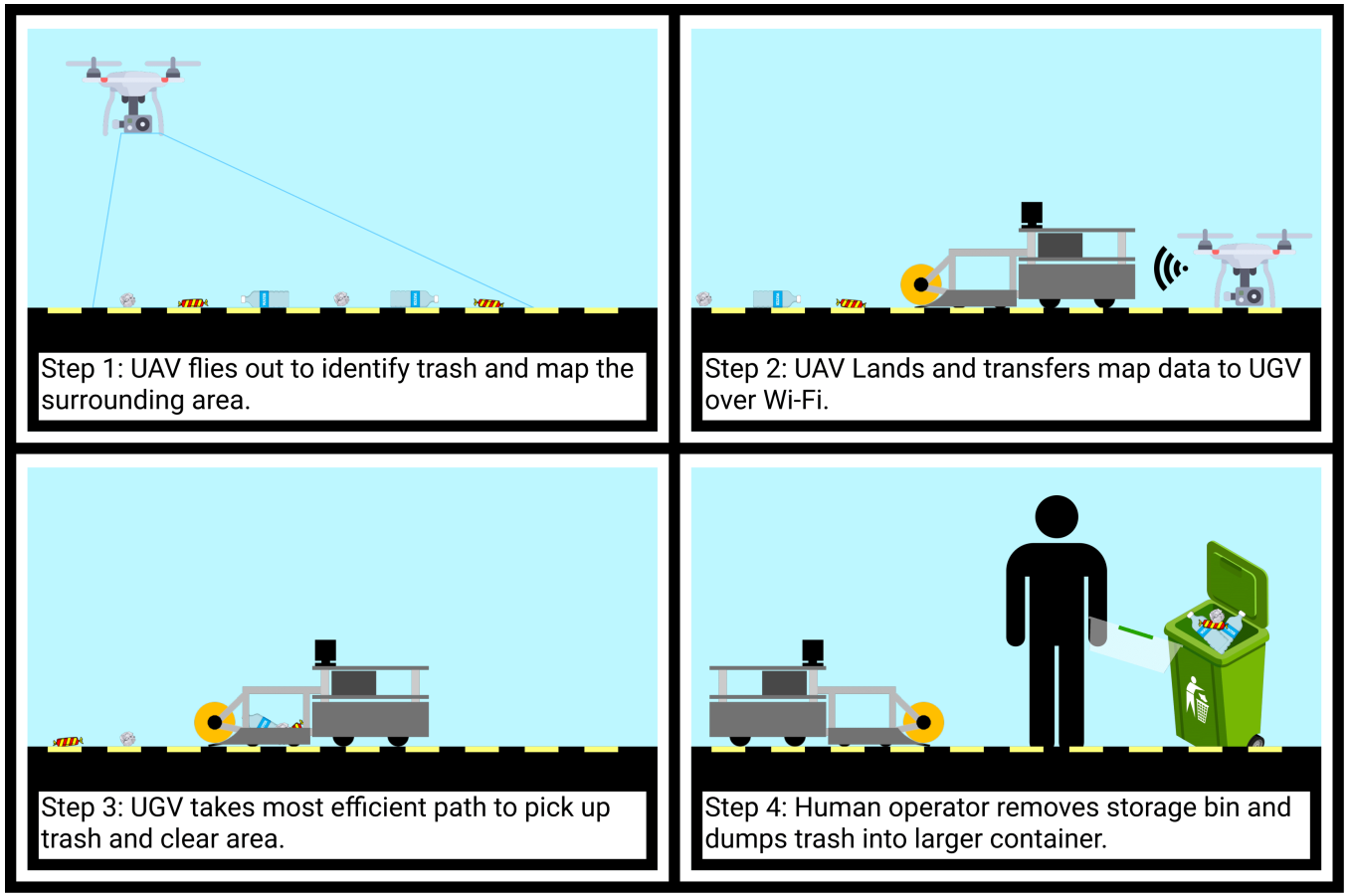
Path Planning



- Path planning framed as a solution to the **Traveling Salesman Problem** and is **solved on the U.G.V.**
- After the U.G.V. has localized itself within the map and determined the trash cluster nodes which it needs to reach, it will determine the shortest path between on the points.

Costs

	Vendor	*Unit Price ($)*	*Quantity*	*Total Price ($)*
TurtleBot 2 - Kobuki Robot - Intel NUC Computer - Microsoft Kinect - Robot Frame - Charger	Borrowed	N/A	1	0.00
DJI Matrice 600 Pro - Camera - Charger	Borrowed	N/A	1	0.00
Arduino Uno	Owned	N/A	1	0.00
Photoresistor	Owned	N/A	1	0.00
Adafruit DRV8871	Adafruit	7.50	1	7.50
5mW 600nm Laser Diode	Adafruit	5.95	1	5.95
Male-Female Breadboard Wires	Owned	N/A	<20	0.00
Double-Sided PCB Perfboard	Owned	N/A	1	0.00
Male PCB Header Pins	Owned	N/A	<20	0.00
Female PCB Header Pins	Owned	N/A	<20	0.00
AmpFlow P40-250 Brushed Electric Motor	Amazon	64.70	1	64.70
Rotary Brush	AUTC	TBD	TBD	TBD
80/20 Extruded Aluminum	TBD	TBD	TBD	TBD
Sterilite Clip Storage Box - Green	Target	7.99	1	7.99
Screws	TBD	TBD	TBD	TBD
Soldering Iron	Owned	N/A	1	0.00
Solder	Owned	N/A	1	0.00
22 AWG Solid Core Wire Kit	Amazon	13.99	1	13.99
Total Price				**$100.13**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Questions