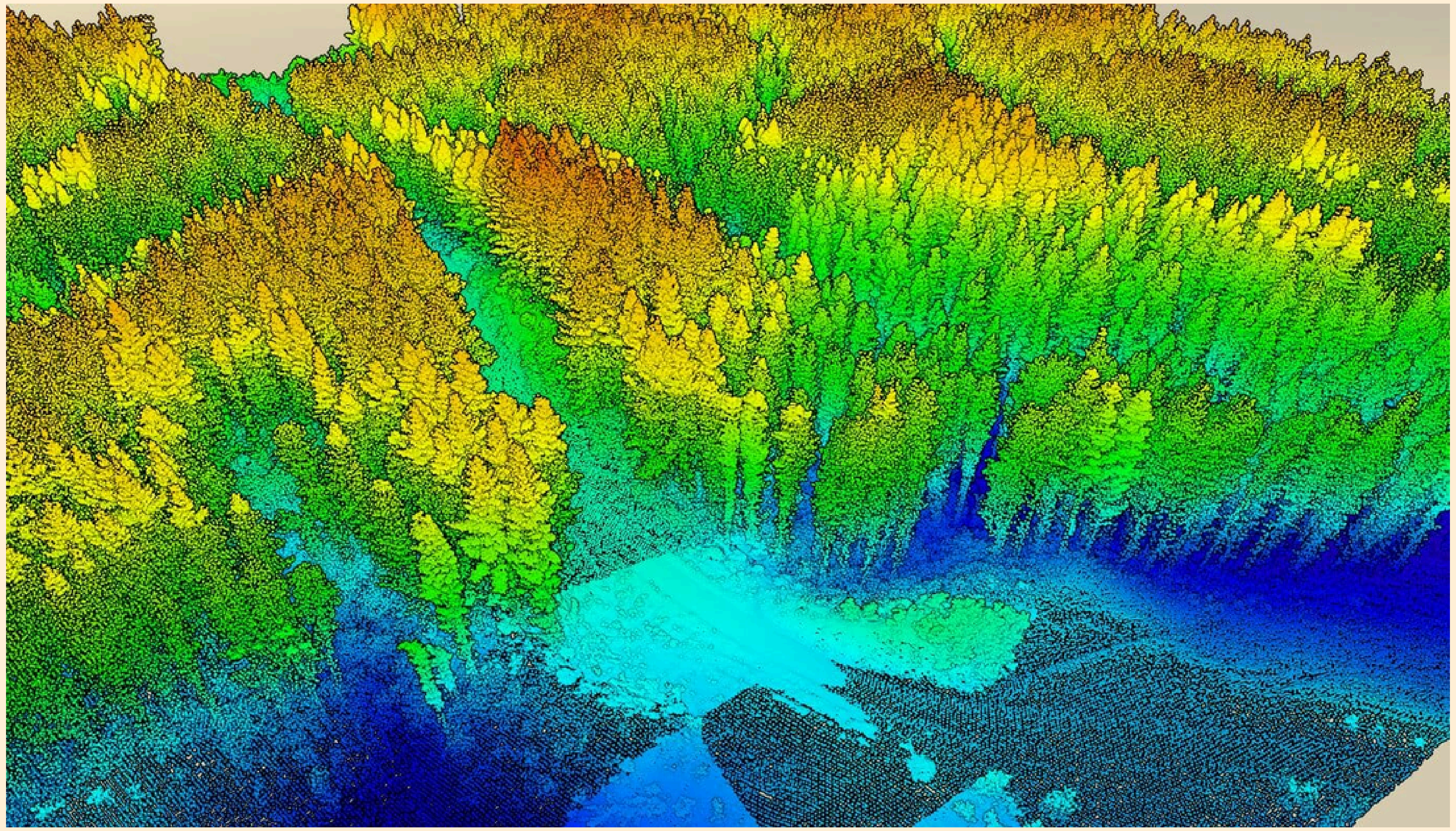
BTECH SEMESTER III : EE207 - ELECTROMAGNETIC THEORY

GENERATION OF ENVIRONMENT MAP USING ICP BASED POSE SLAM AND EXTRACTION OF FOREST METRICS FROM IT

Aakash Mallik – 2110802
Gaurangee Parashar - 2110510
Shah Charu Samir - 2110286

ELECTRICAL AND ELECTRONICS ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
KARNATAKA

INTRODUCTION



Aim

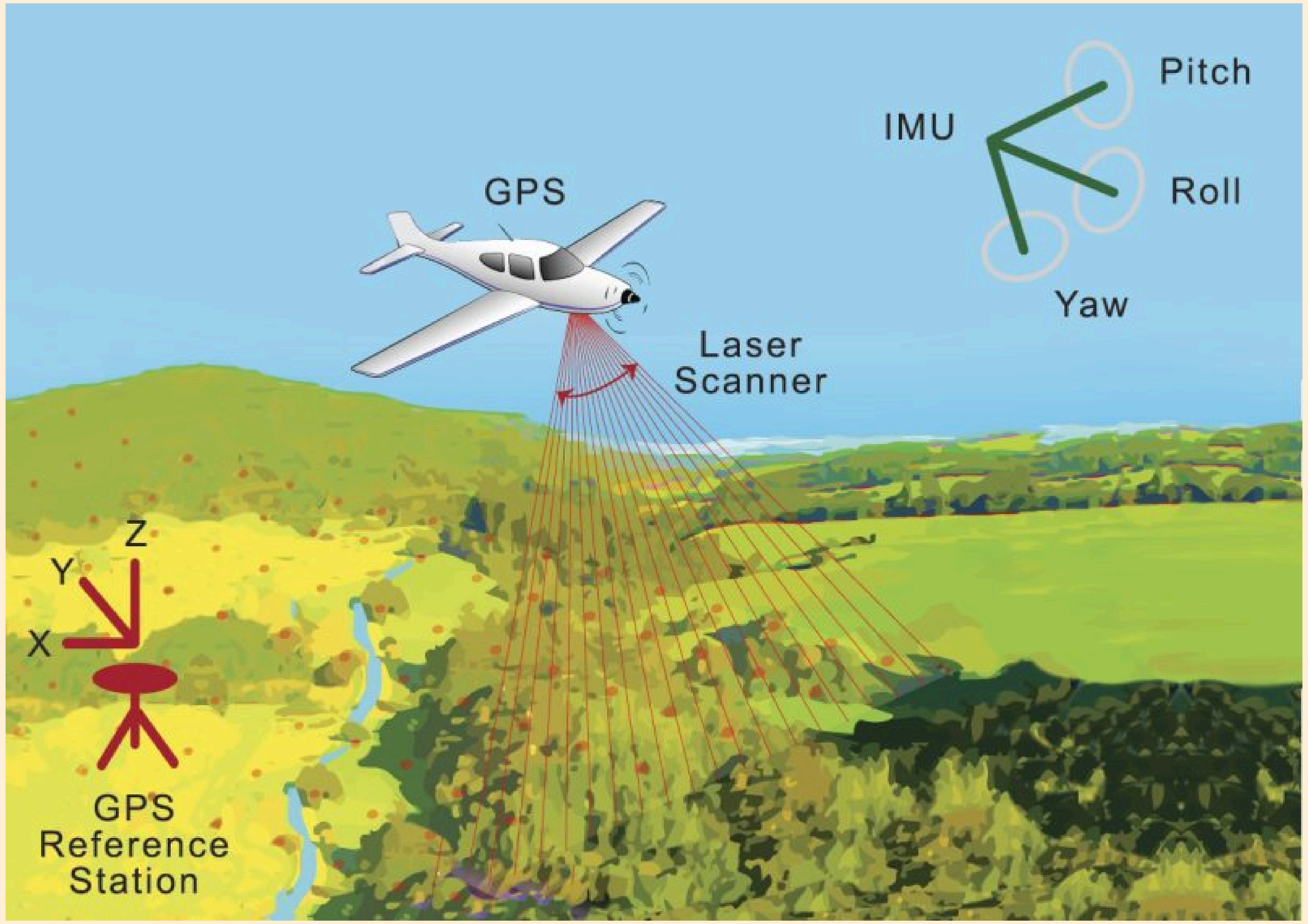
To simulate a map of the environment that a drone traverses and optimise the trajectory of its movement. We also take a look into how lidar scanned data point map clouds are pivotal in forestry analysis.

LIDAR SYSTEMS

Light Detection And Ranging or Laser Imaging, Detection, And Ranging

It is a remote sensing method for determining ranges by targeting an object with a laser and measuring the time for the reflected light to return to the receiver

COMPONENTS OF A LIDAR SYSTEM



Laser source

Generates the energy of the pulses.

Laser detector

Detects the laser light pulses that are reflected back from the target objects.

Timers

Record the exact time the laser pulse leaves and returns to the scanner.

Global Positioning System

Records the precise X, Y, Z location of the scanner.

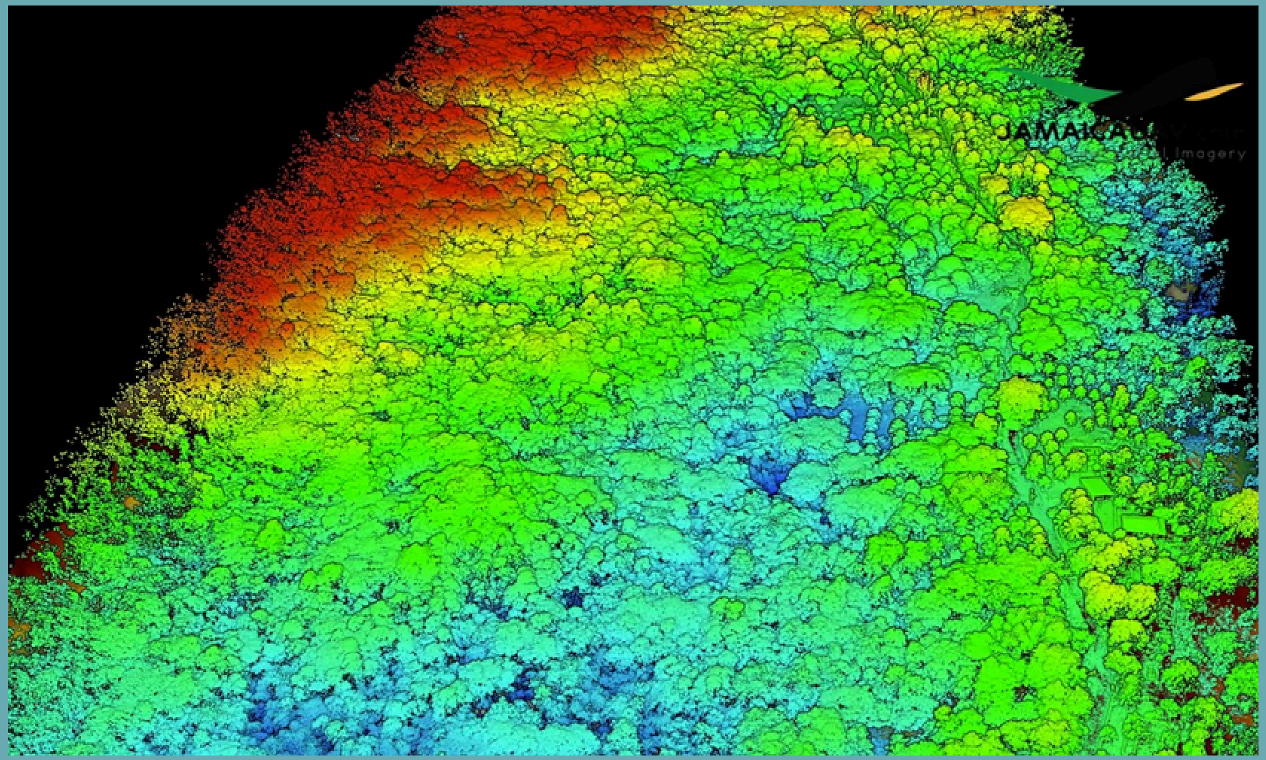
Inertial Measurement Unit

Contains an accelerometer, gyroscope, and magnetometer sensors that measure the velocity, orientation, and gravitational forces.

Computer System

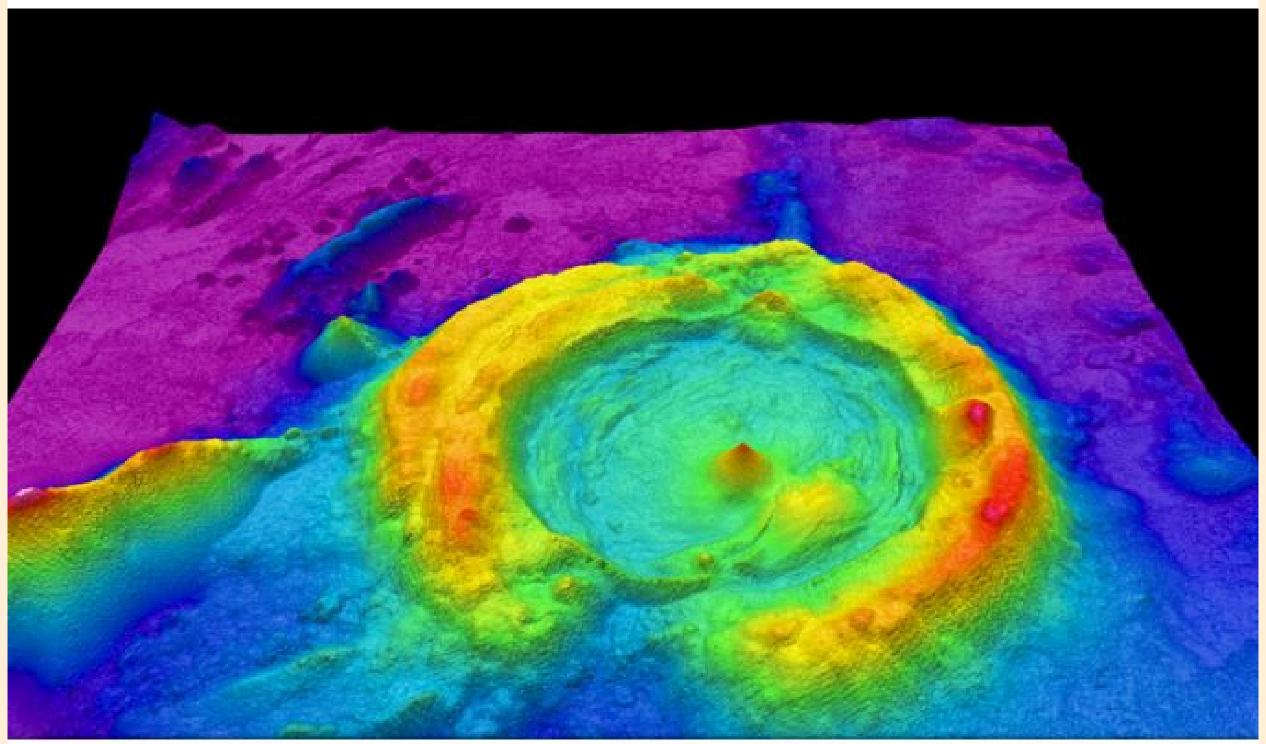
Integrates the data from the laser system, the GPS and the IMU to produce the lidar point data.

TYPES OF LIDAR



Topographic LiDAR

Uses a near-infrared laser to map the land.



Bathymetric LiDAR

Uses water-penetrating green light to also measure seafloor and riverbed elevations.

DETECTION OF THE OPTIMAL TRAJECTORY OF THE DRONE AND GENERATION OF THE ENVIRONMENT MAP

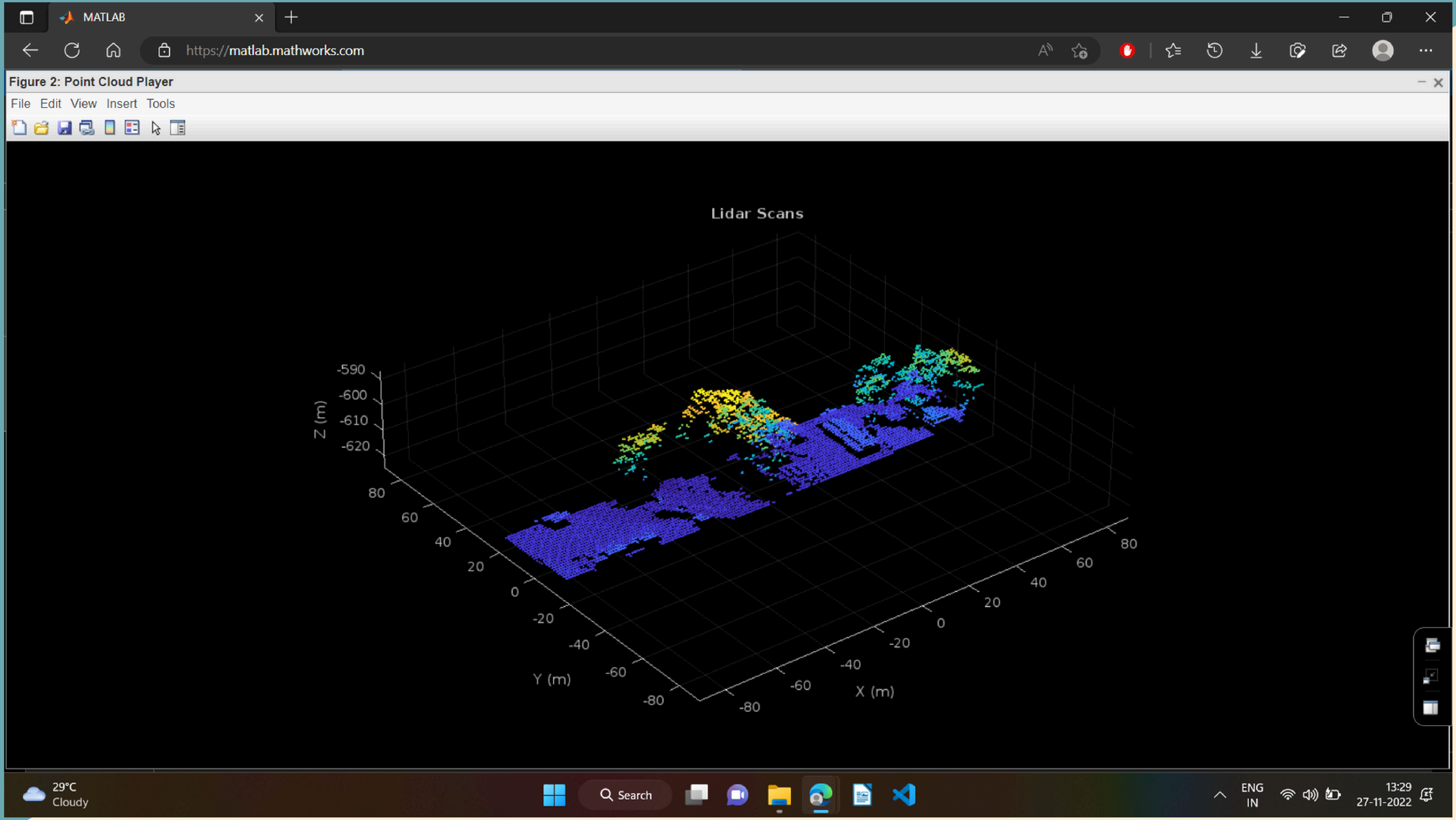
HOW TO DO IT?

- SLAM algorithm estimates a trajectory by finding a coarse alignment between downsampled accepted scans.
- It uses fast point feature histogram (FPFH) descriptors extracted at each point.
- Then applies the iterative closest point (ICP) algorithm to fine-tune the alignment.
- 3-D pose graph optimization, from Navigation Toolbox™, reduces the drift in the estimated trajectory.

STEP 1 : EXTRACTING FPFH DESCRIPTORS FROM DATA POINTS

- **Compute lidar scans from the data at each waypoint of the drone using the helperCreateDataset function**
- **Downsampling of lidar scans**
- **Extraction of FPFH descriptors**
- **Creation of submaps**

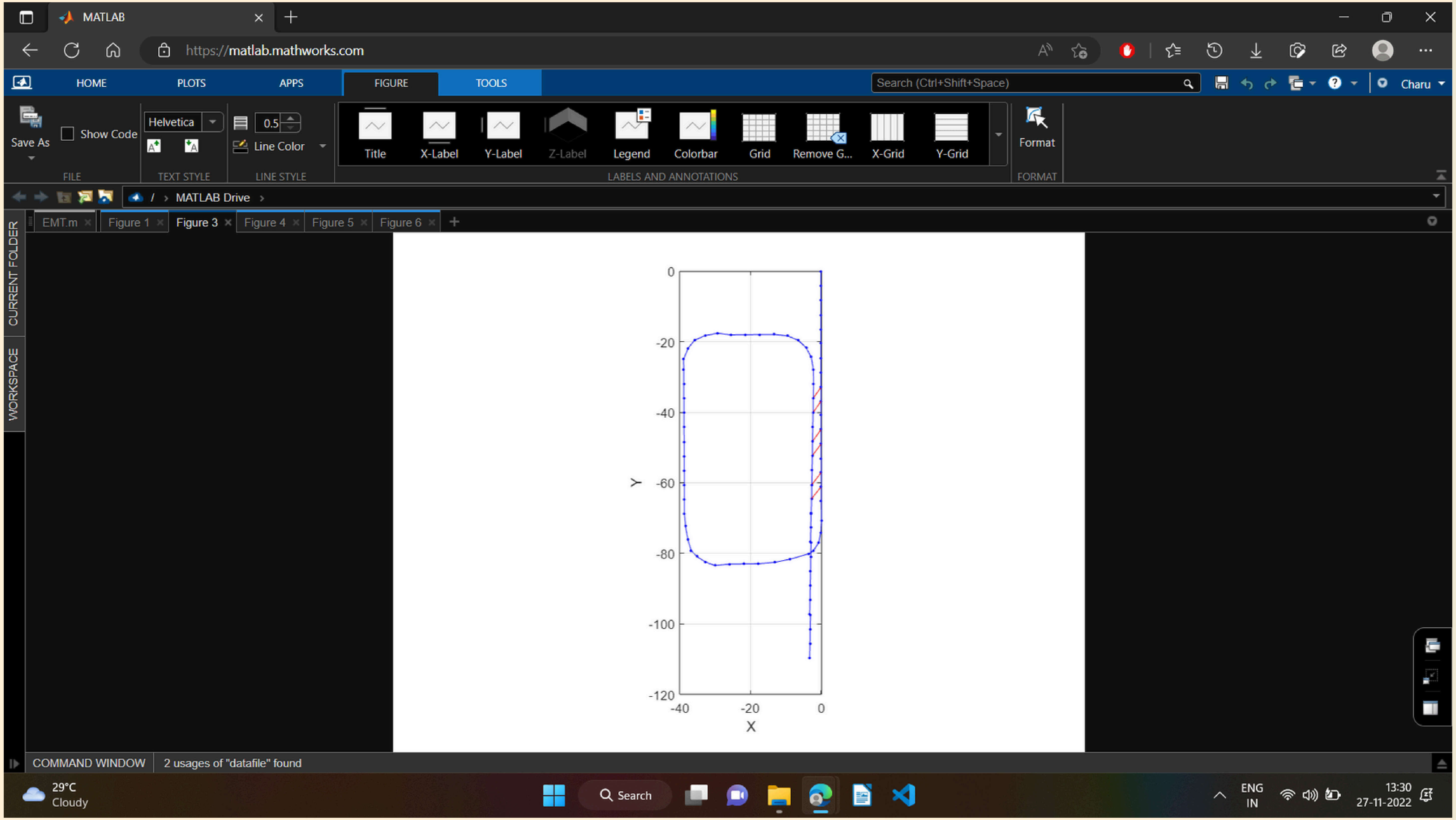
Downsampled Lidar scans



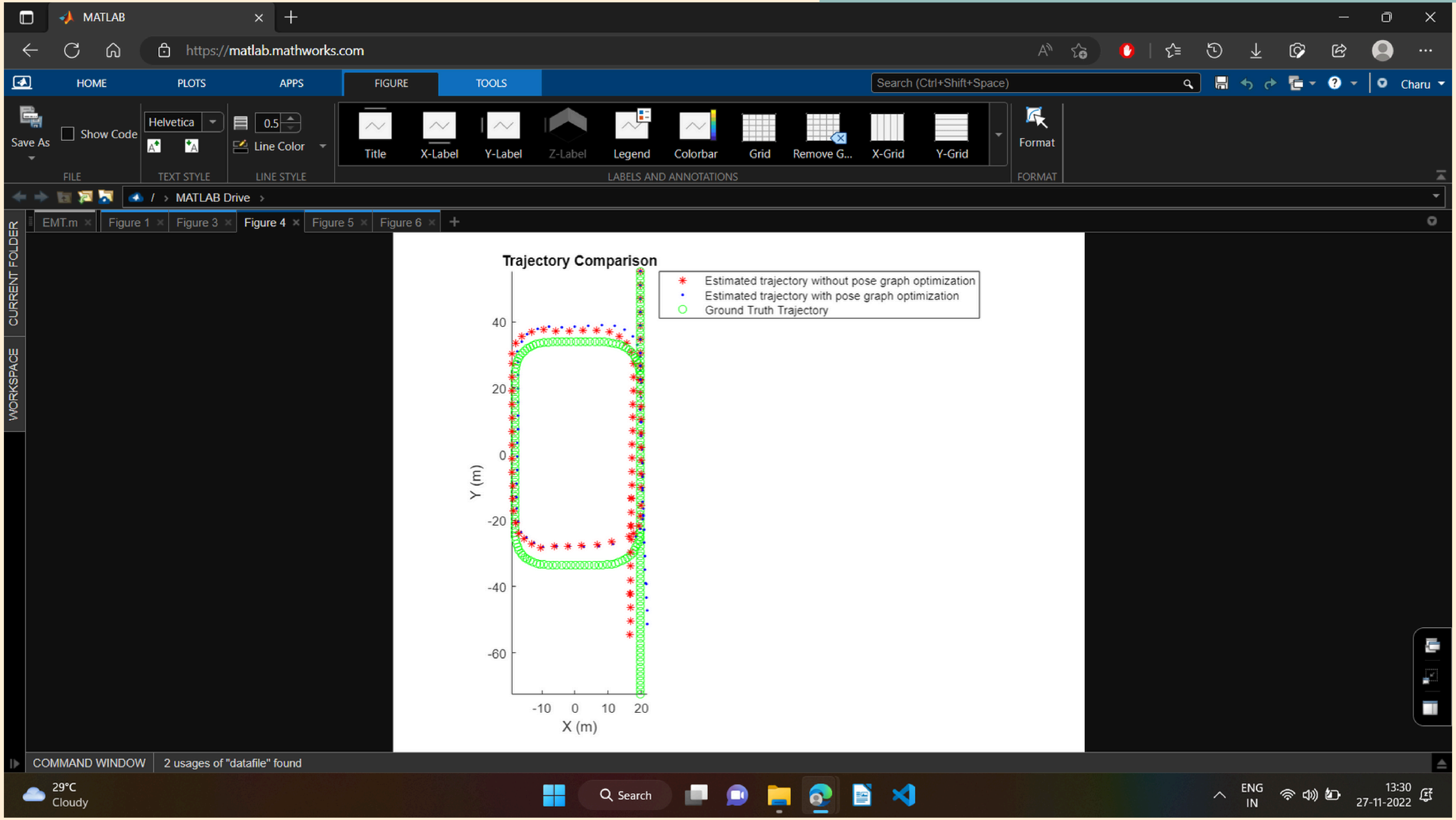
1. Using the helperEstimateLoopCandidates function we can estimate matches between previous submaps and the current scan.
2. Use of ICP registration algorithm.

STEP 2 : LOOP CLOSURE USING ICP

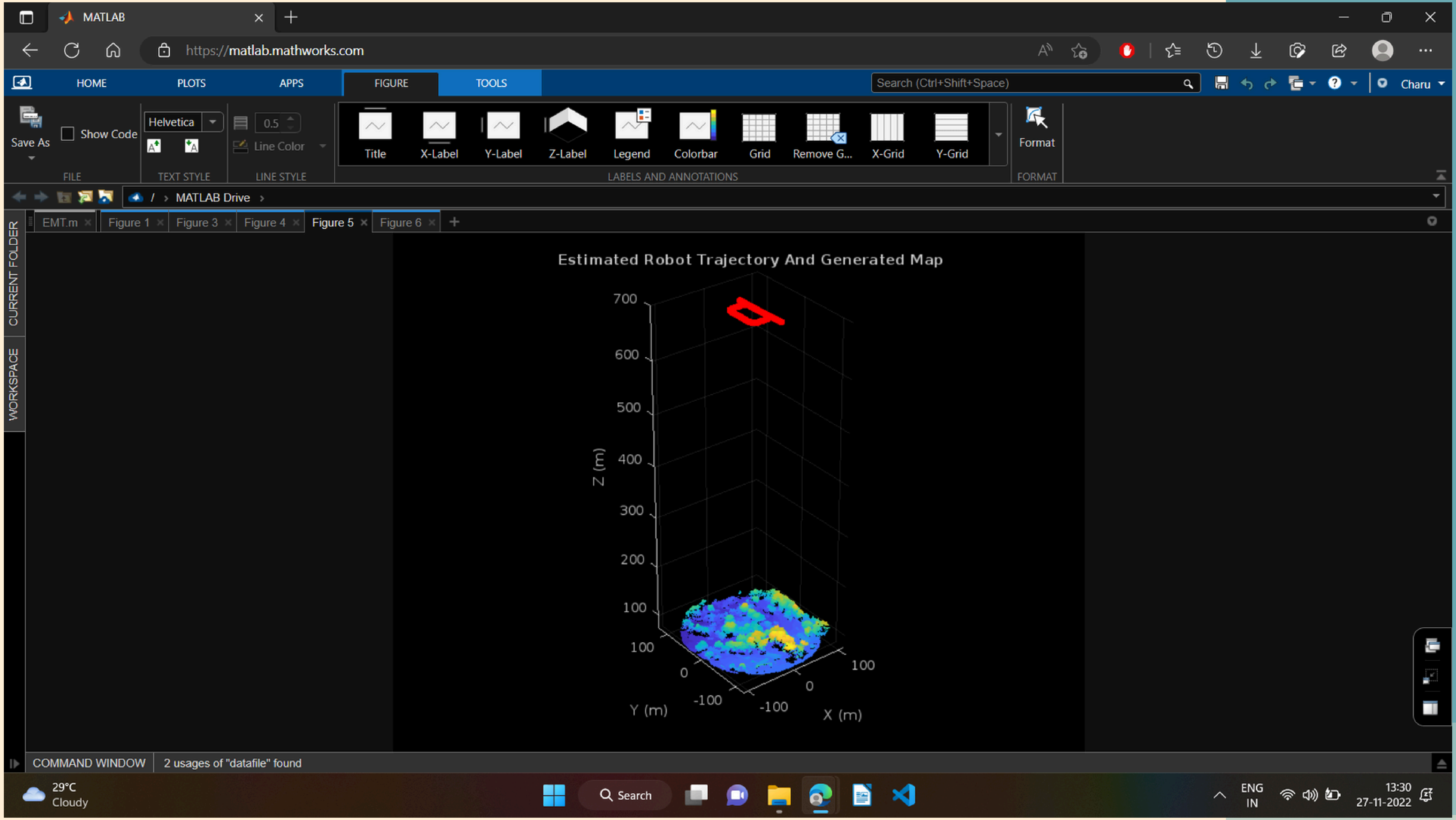
Loop closure using ICP



STEP 3 : POSE GRAPH OPTIMIZATION

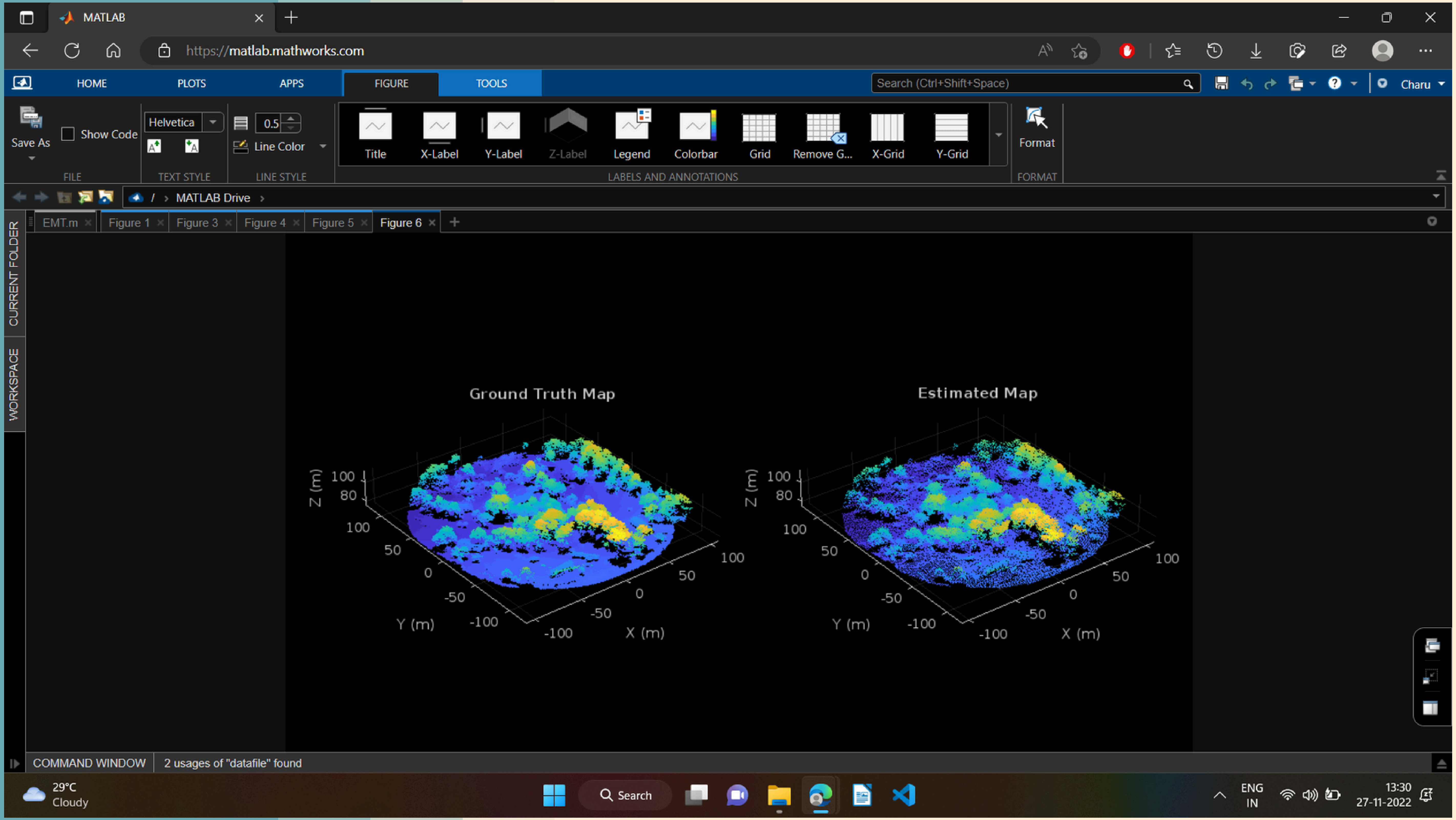


Optimisation of drone trajectory



Visualisation of the estimated trajectory and generated map

Comparison between ground truth map and estimated map

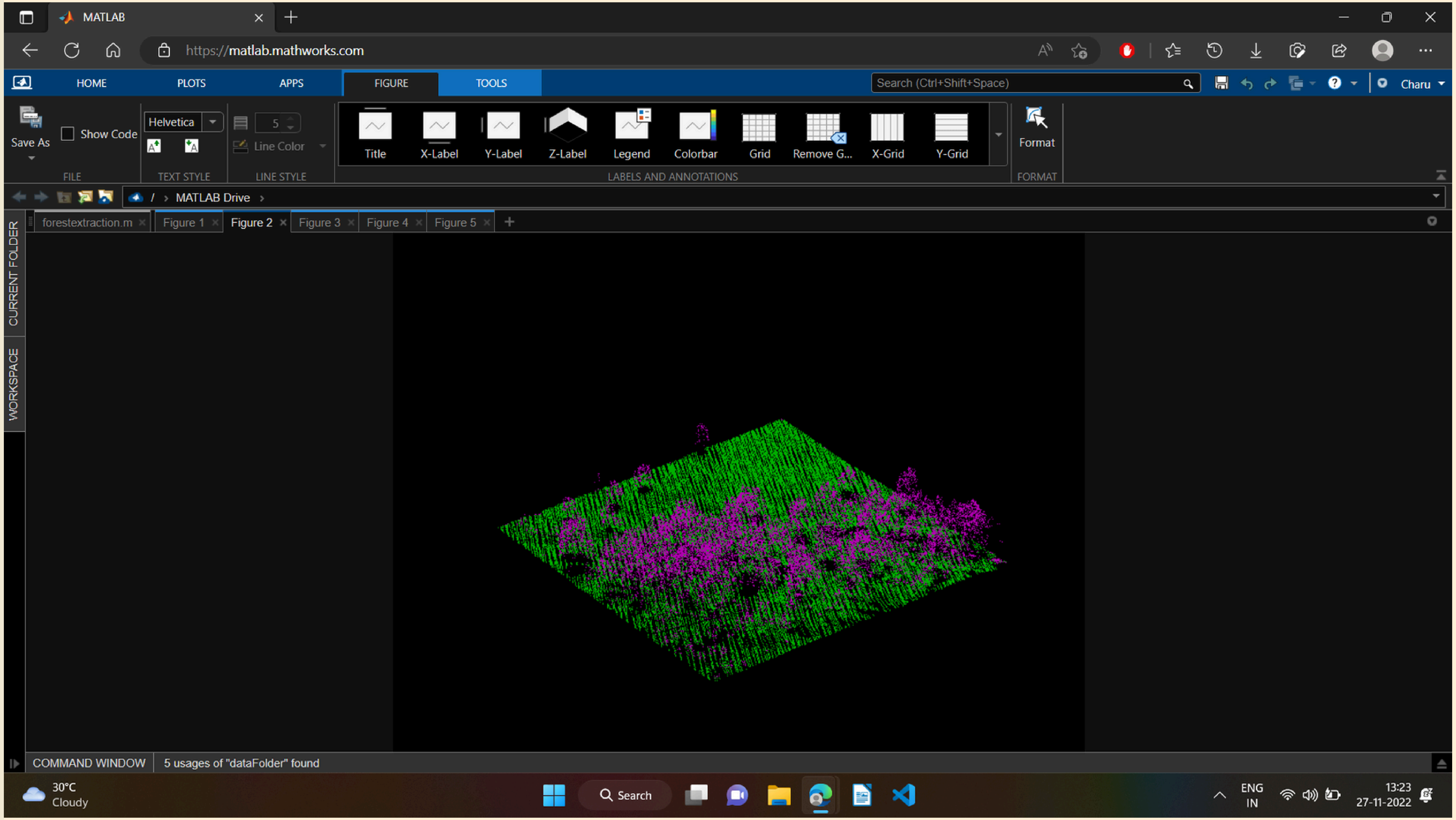


Thus implementing ICP using pose graph optimisation yields an environment map with greater levels of accuracy!

IMPLEMENTATION OF FOREST ANALYSIS MODEL

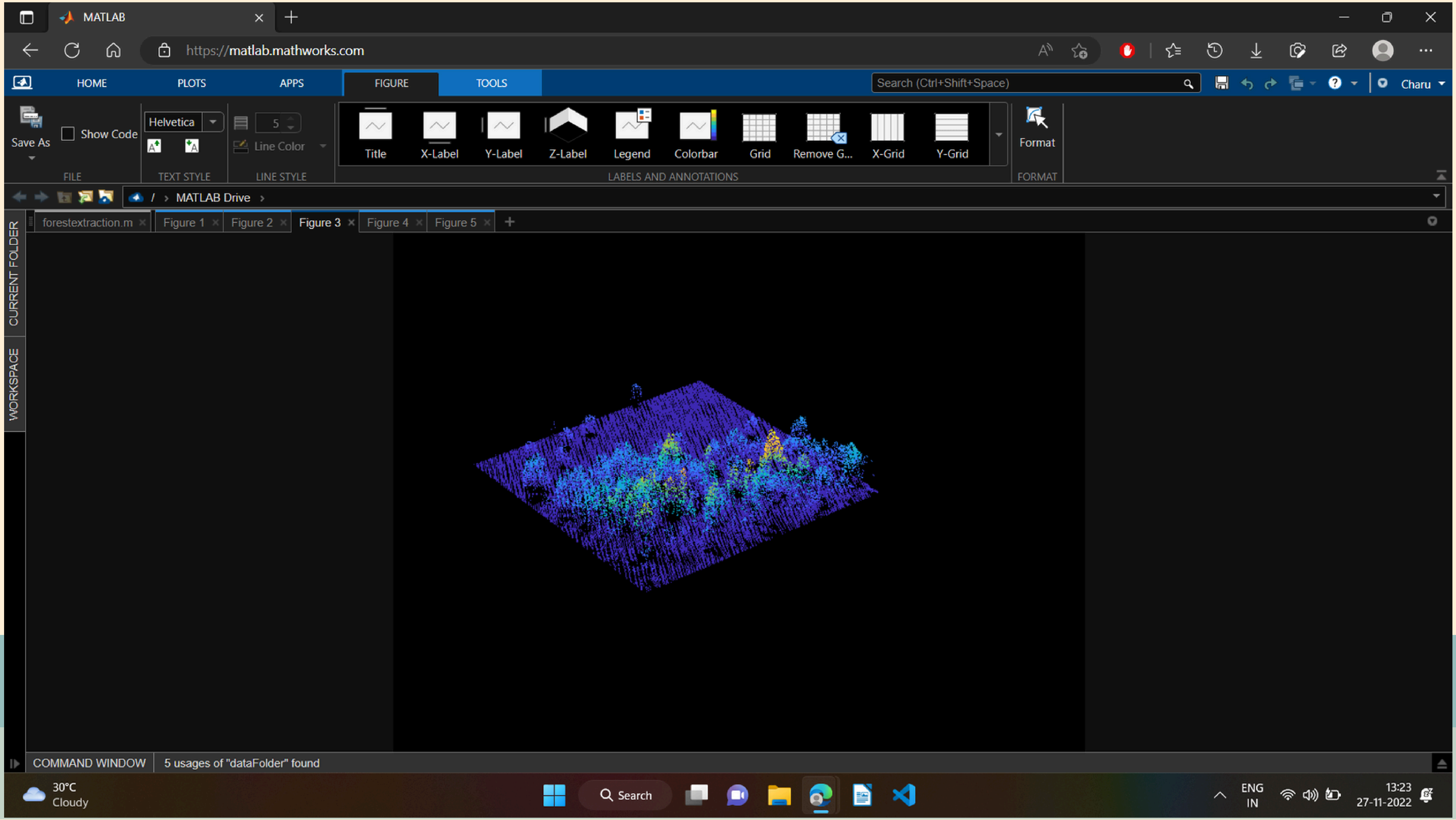
STEP 1 : DATA PRE-PROCESSING

- Ground segmentation
- Elimination of duplicate points
- Normalisation of elevation



GROUND SEGMENTATION

Visualisation of environment map after duplicate point removal



STEP 2 : EXTRACTION OF FOREST METRICS

Canopy Cover

the proportion of the forest covered by the vertical projection of the tree crowns.

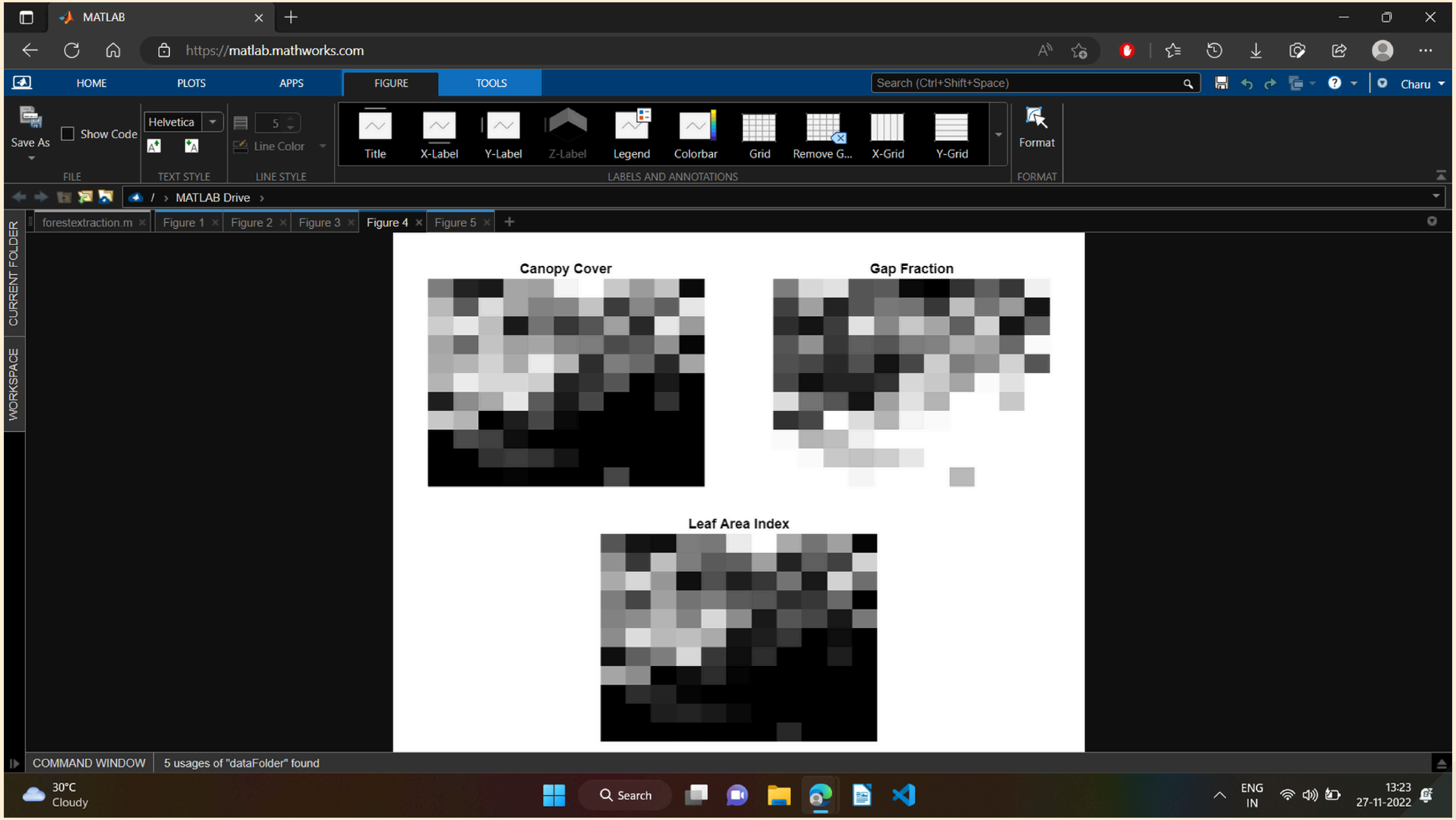
Gap fraction

the probability of a ray of light passing through the canopy without encountering foliage.

Leaf area index

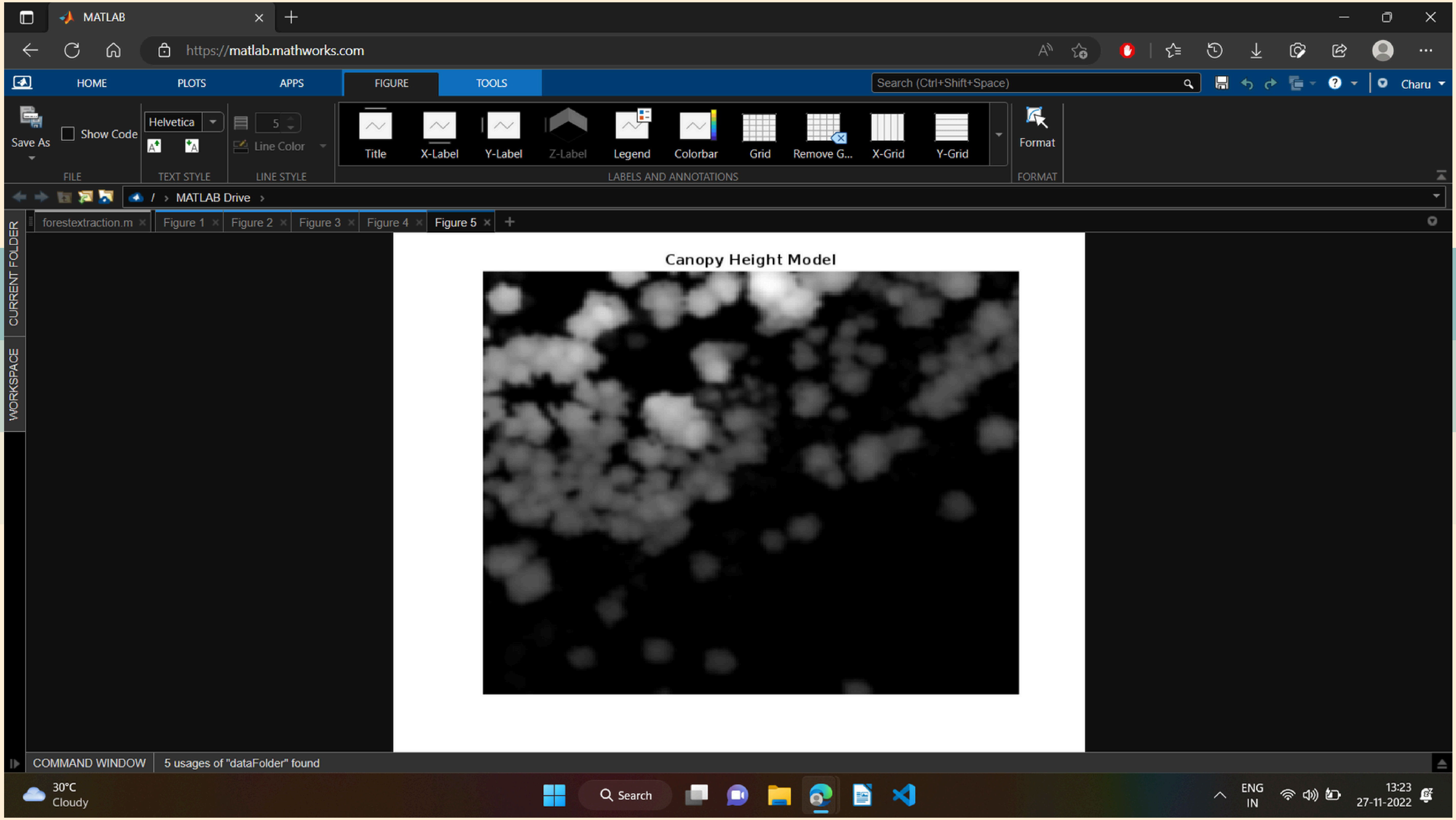
the amount of one-sided leaf area per unit of ground area.

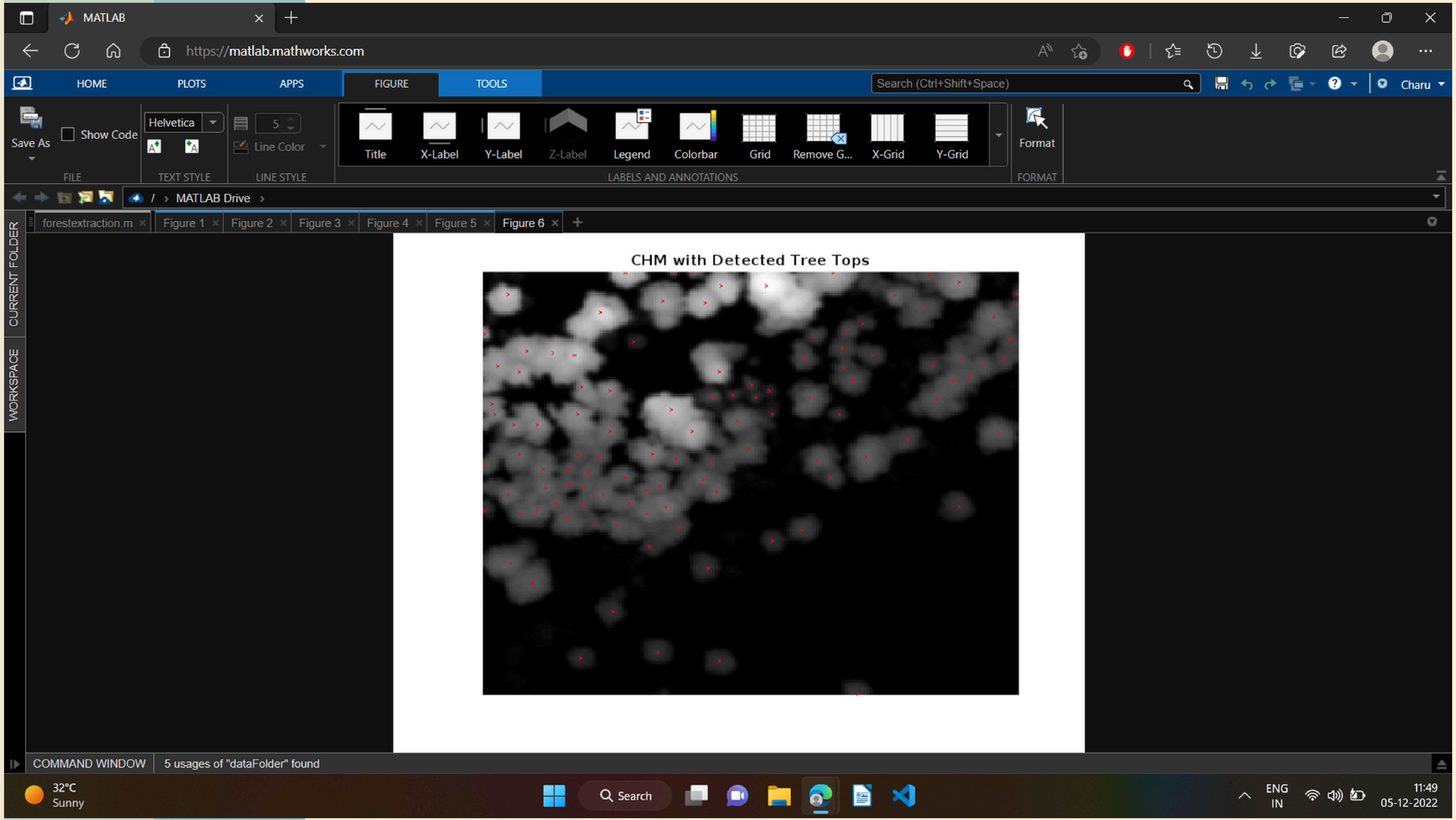
Extraction of forest metrics from the input map



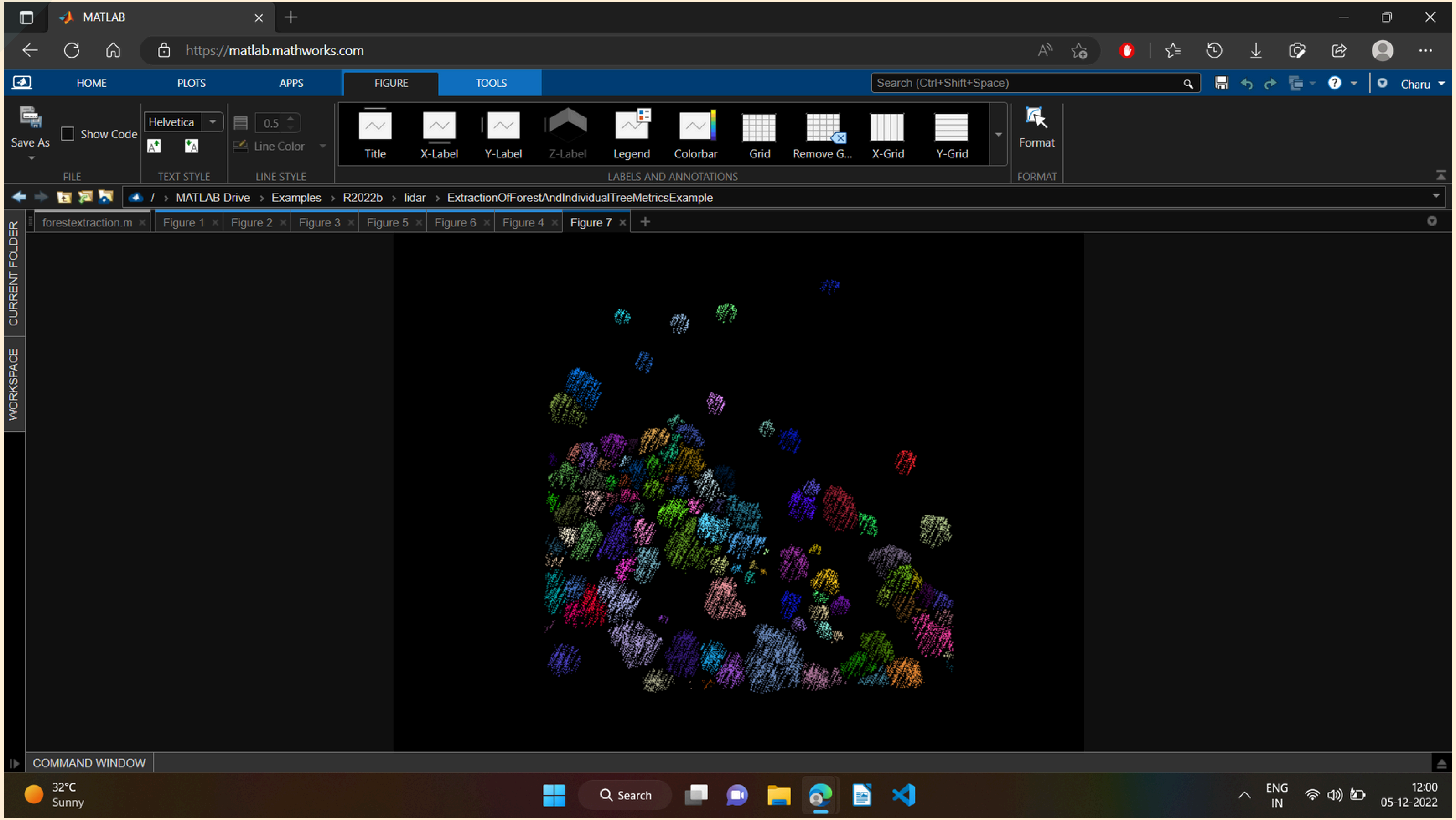
Step 3 : Extraction of individual tree attributes

Visualisation of the generated CHM



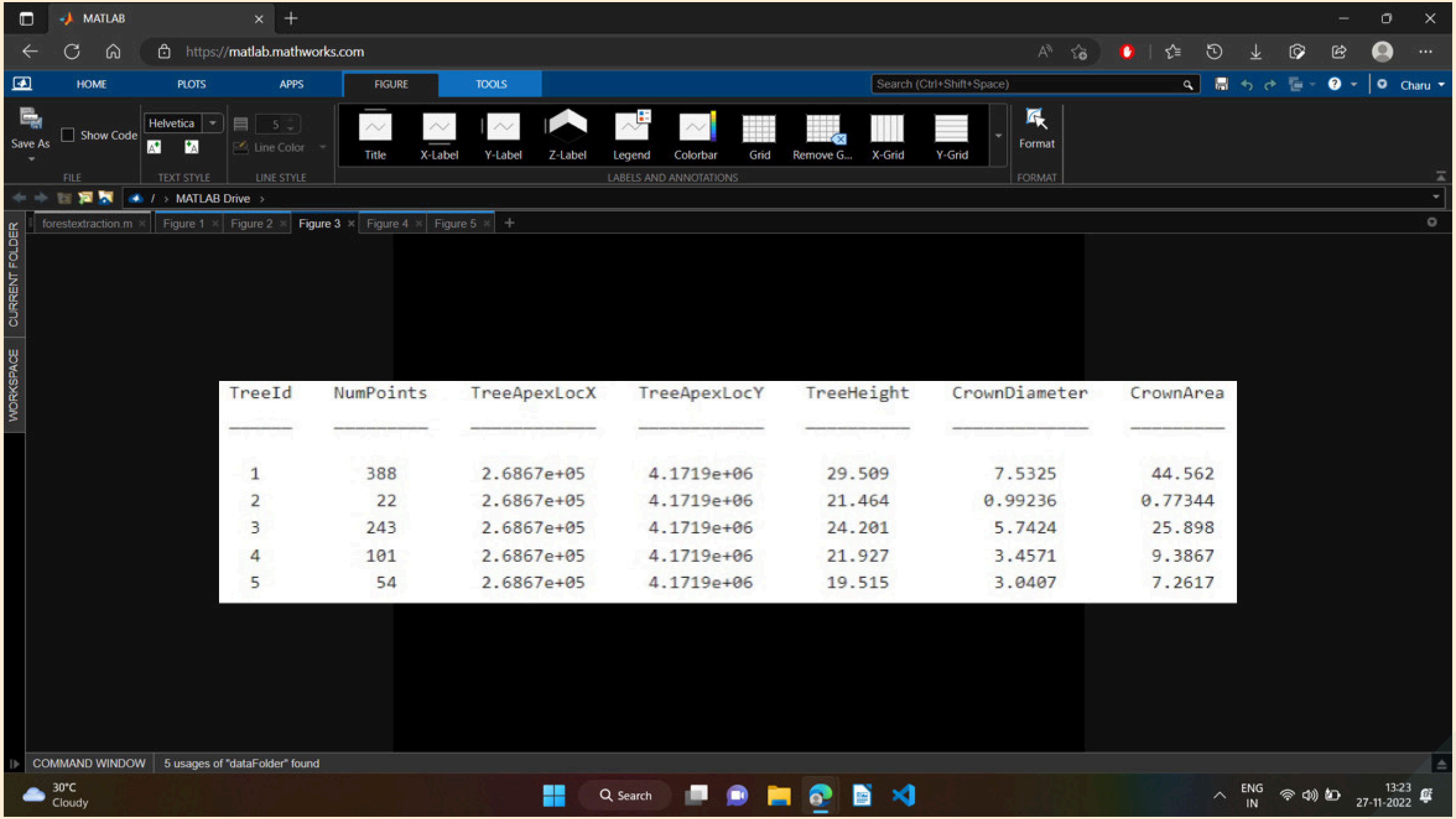


Identification of individual trees in CHM



Segmentation of individual trees

Extraction of individual tree attributes



TreeId	NumPoints	TreeApexLocX	TreeApexLocY	TreeHeight	CrownDiameter	CrownArea
1	388	2.6867e+05	4.1719e+06	29.509	7.5325	44.562
2	22	2.6867e+05	4.1719e+06	21.464	0.99236	0.77344
3	243	2.6867e+05	4.1719e+06	24.201	5.7424	25.898
4	101	2.6867e+05	4.1719e+06	21.927	3.4571	9.3867
5	54	2.6867e+05	4.1719e+06	19.515	3.0407	7.2617

THANK YOU!