Autonomous Landing Of A Drone Using Deep Neural Networks

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INTRODUCTION

- Drones are a part of technological advancement in the fields of military, logistic, transport, etc.
- We know that, with manually operated drones it is seldom hard to access remote areas. To overcome this anomaly, unmanned aerial vehicles or UAVs come into picture.
- The goal is to improve landing precision of the drone using DNNs with spectrally normalized weight matrices for enhancing the controller performance when soft landing.

METHODOLOGY [1]

Algorithm for calculating speed of the drone using background subtraction method:

Step 1: Extract images from the camera fitted on the drone when it starts landing.

Step 2: Find a target spot for landing by using background subtraction method.

Step 3: Detect a target spot in each foreground image and generate a blob object each time.

Step 4: Filter out the area in the background of the blobs or the regions outside the selected area.

Step 5: To calculate the distance of the target spot from the drone, store the frame numbers from the entry point to the current point of the drone.

Step 6: Calculate the number of frames lapse between the entry and current points of the drone.

Step 7: Compute the speed of the drone using the following equation,

$$s = (n * d)/FPS$$

Where, n = number of frames elapsed from the entry frame to the current frame

d = the mapping of the frame coordinates to real world coordinates of the video

FPS = frames per second

METHODOLOGY [2]

Algorithm to evaluate generalization performance of the drone using deep neural networks:

Step 1: Bench Test

First measure the mass(m) and diameter of the drone(D), air density(ρ).Perform the bench test to determine thrust constant (CT) as well as the non-dimensional thrust coefficient.

Step 2: Real world flying and data pre-processing

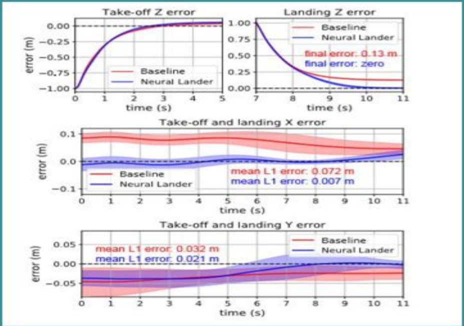
Fly the drone at various heights to estimate the disturbance force. Collect the sequence of state estimates and controlled inputs as our training dataset, which is divided into 2 parts- (i) To learn ground effect. (ii) To learn other aerodynamic forces such as air drag.

Step 3: Deep neural network prediction performance

Train a rectified linear units network(ReLU). Build ReLU using PyTorch. It consists of 4 fully connected hidden layers with input dimension equal to 12 and output dimension equal to three. Use spectrum normalization to constrain Lipschitz constant of the neural network and compare the near ground estimation accuracy of DNN with existing one dimensional steady ground effect model.

TESTING (1)

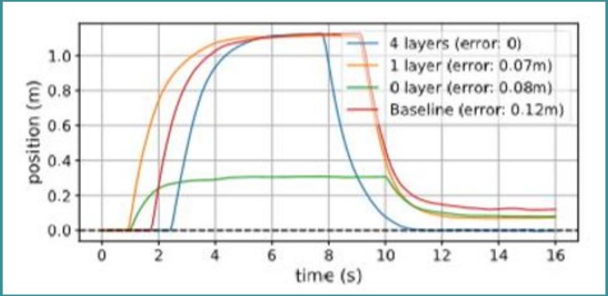
Comparing take off and landing performance:



Autonomous drone lands on the ground smoothly and precisely. Where as, due to the ground effect, the baseline controller struggles to achieve zero terminal height. with DNN, the drone learns about the additional aerodynamics such as air drag. Hence, it can mitigate drifts in the x-y plane

TESTING (2)

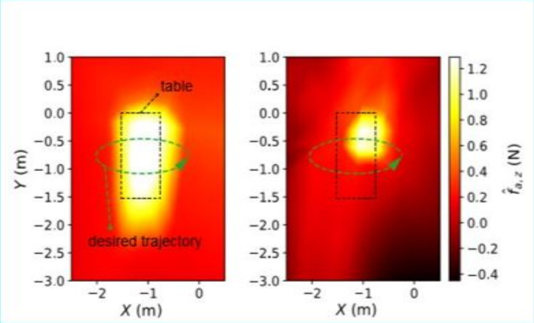
Comparing drone performance with different DNN capacities



1 layer model decreases the z error but it is still not enough to land a drone. Also the 0 layer model generates significant error during takeoff.

TESTING (3)

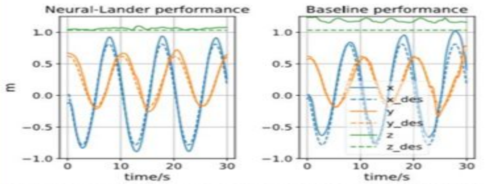
Trajectory tracking performance:



Heat maps of learned f(a,z) versus x and y, with other inputs fixed.(Left) ReLU network with spectral normalization(Right) ReLU network without spectral normalization. W e can see that the spectrally normalized DNN shows a clear table boundary.

TESTING (4)

Comparing the trajectory tracking performance of autonomous drone with baseline controller



Mean X error	**0.079m**	0.126m
Mean Y error	**0.052m**	0.061m
Mean Z error	**0.027m**	0.153m
Z variance	**0.014m**	0.026m

The autonomous drone with DNN outperforms the baseline controller in all the X,Y,Z axes. Much smaller tracking errors are seen in autonomous drone which uses spectrally normalized DNN.

CONCLUSION

The main benefits of an autonomous drone are:

1. The autonomous drone provides more accurate estimates with less error percent-age than theoretical ground effect model.
2. It outperforms conventional drones on X, Y and Z axes as it can capture both the ground effects and other non-dominant aerodynamics.
3. The stability of the controller is guaranteed and it also employs generalization to unseen domains.
4. Unmanned Aerial Vehicles (UAVs) have a greater range of movement that manned aircrafts. We are able to fly at lower and more distinct angles allowing them to easily navigate through the traditionally hard-to-access areas.

REFERENCES

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Thank You