SADI

CODENAME: INDIANA DRONES

by

Derek Hollenbeck, from Mechanical Engineering

Jeremias Gonzalez, from Physics

Katherine Shurik, from Interdisciplinary Humanities

Project Background

Dr. David Burger, from NASA Armstrong posed the research question,

Can we model sUAS performance characteristics and design trajectories to capture needed details for archaeology sites?

Which needed the following background questions,

- What is the current problem with finding archaeology sites?
- What are the current limitations?

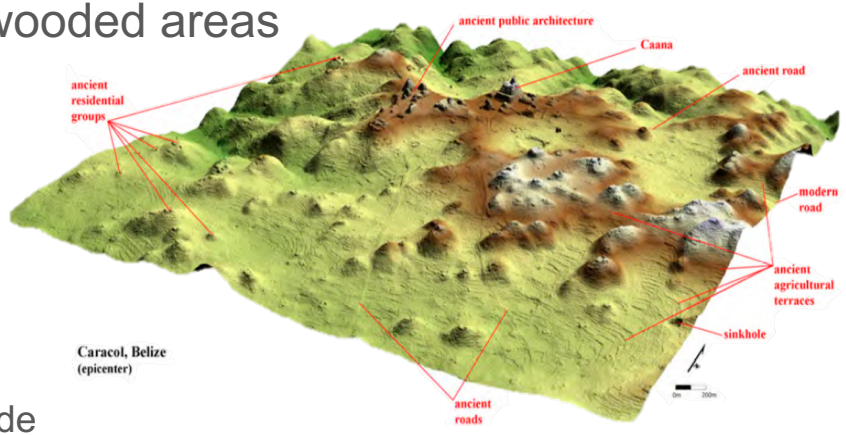
Project Difficulties – Lidar Capabilities

Light Detection and Ranging (LiDAR) is a technique used to measure distances based on light reflection

LiDAR has been used to identify archaeological sites in various environment, especially in heavily wooded areas

LiDAR disadvantages:

- Is very expensive
- Has to cover large areas
- Has to be conducted at high altitude



(Chase et al 2014)

Project Difficulties – sUAS Capabilities/Limitations

Small Unmanned Aerial Systems are physically and legally limited

3DR AERO-M

PERFORMANCE CHARACTERISTICS

• Maximum altitude	400ft (limit by FAA)
• Nominal Endurance	40min*
• Turn rate limits	45°/s
• Maximum gusts	15m/s

Legal Limitations

• Speed Limit	100mph
• Weight Limit	<55lbs
• Visual Line of Sight	Always
• Per RPIC	1 sUAS
• +more	

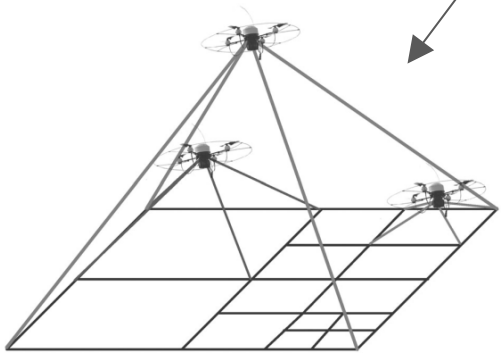
Search Methodology and Trajectory Design

Scanning (Traditional - Brute Force)

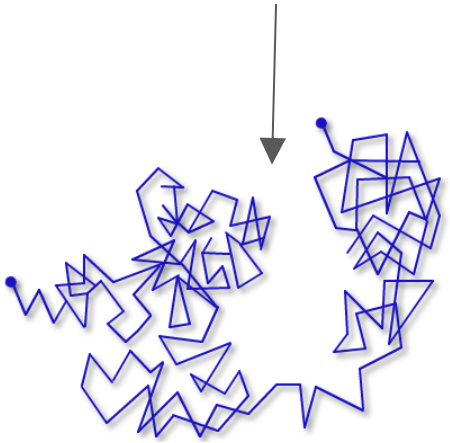
- Can completely cover area of interest (AOI)
- More time consuming for larger areas
- Other variations (such as sliding race track)
- Require tight turns for good overlap (fly outside AOI turn and come back)

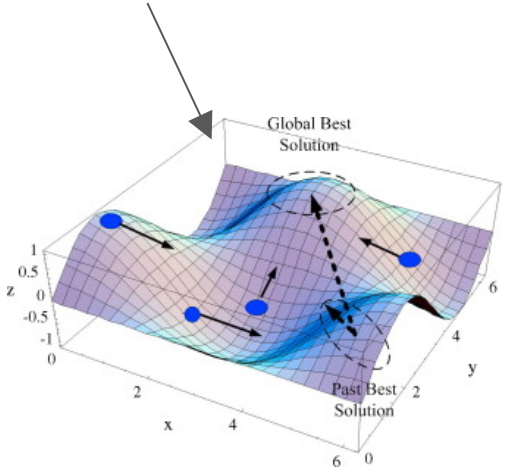
Search Methodology and Trajectory Design

Literature Review (Prob Quad Tree, Brownian Motion, Swarm, etc)



Carpin et al. 2013



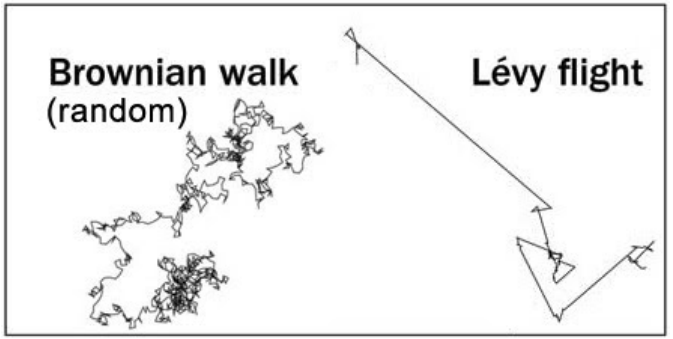


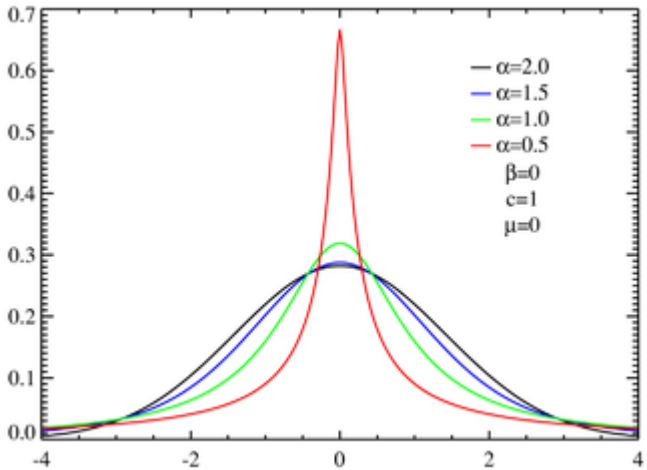
Search Methodology and Trajectory Design

Levy Walk vs Levy Flight

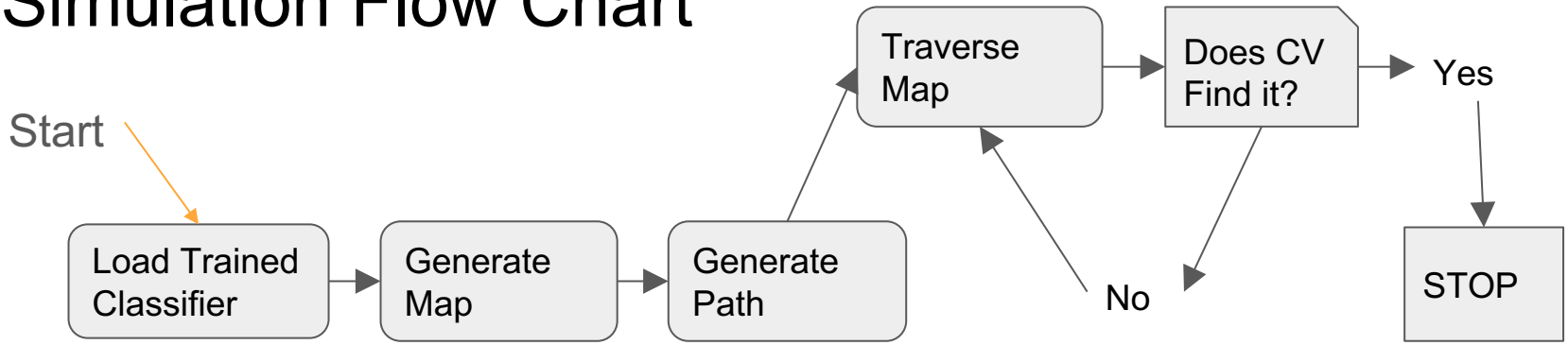
- Large flights can be taken in one time step (large instantaneous velocities)
- Levy walks traverse the same path at a constant velocity

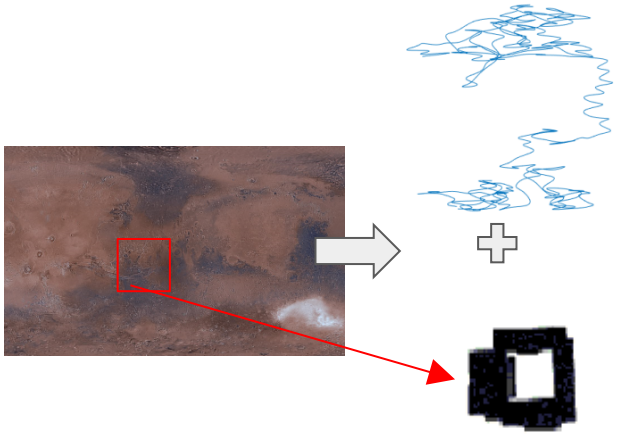
$$p(l_j) \sim l_j^{-\mu}$$

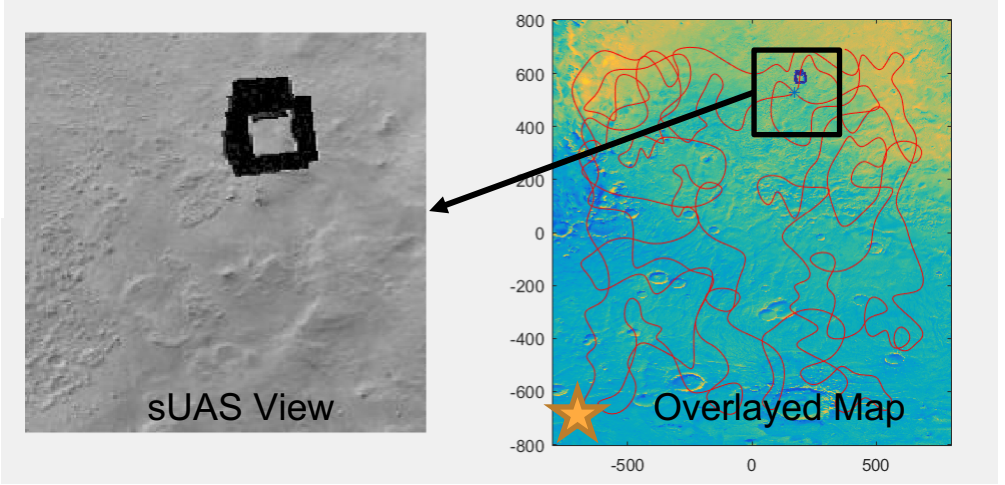




Simulation Flow Chart







Computer Vision Techniques [5]

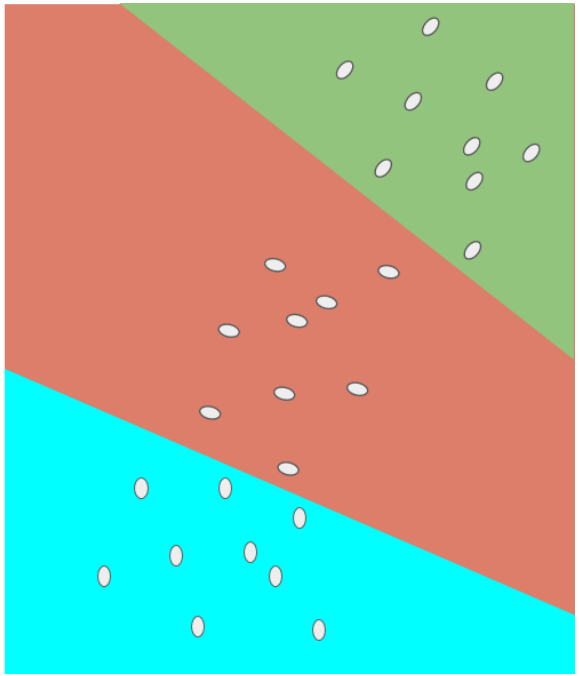
Deep learning

- Best for large data sets
- Small data set overfitting
- Manual weighting/pretrained
- Long runtimes

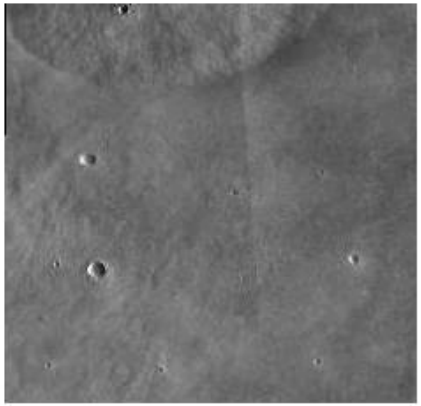
Machine learning

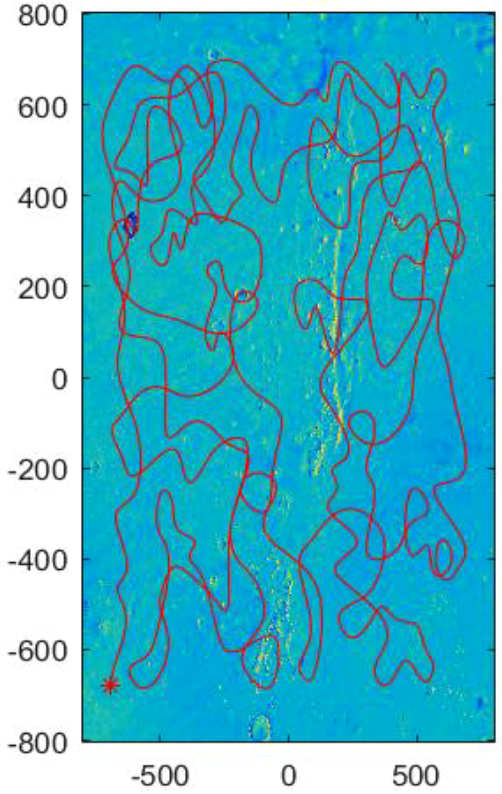
- Small data set = okay!
- Several premade classifiers available
- Very fast

Machine learning more applicable

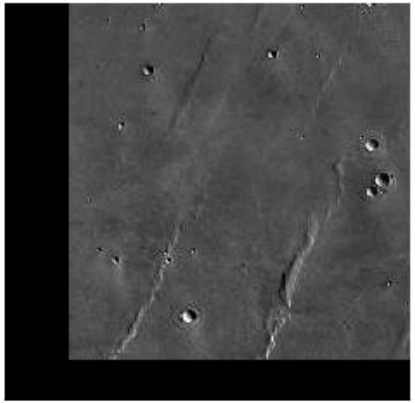


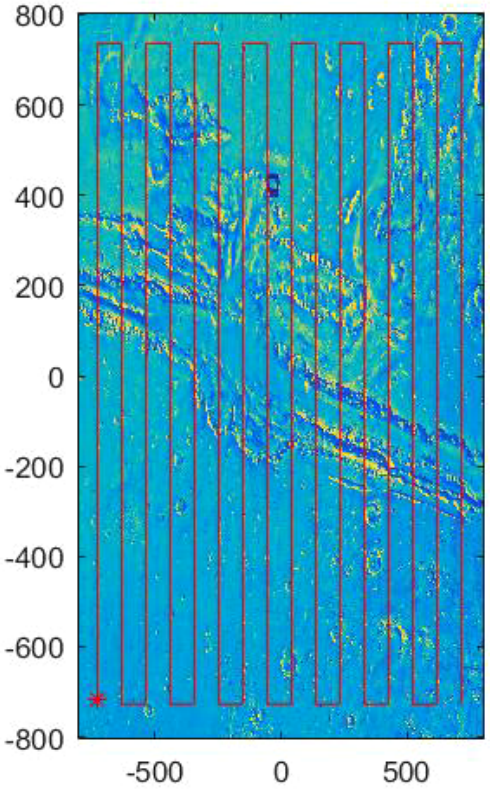
Positive detection of levy walk simulation





False detection of vertical scanning simulation

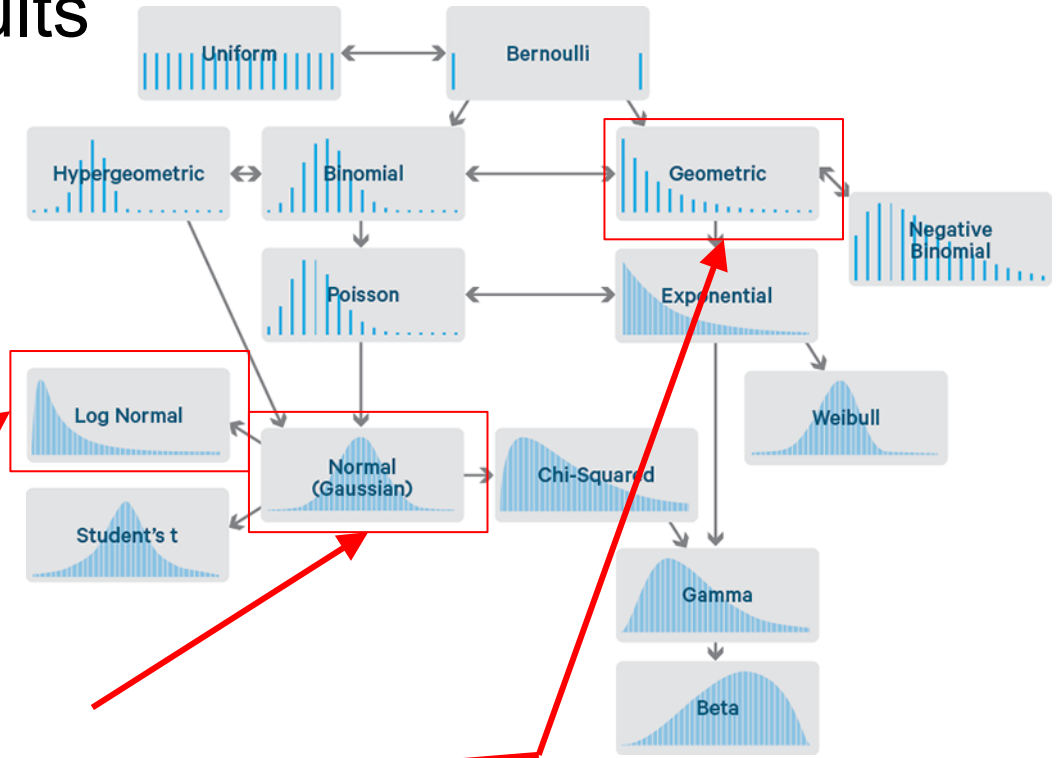




Data Fitting the results

What type of distribution describes the outcome

- Time taken
- Correctly Identified



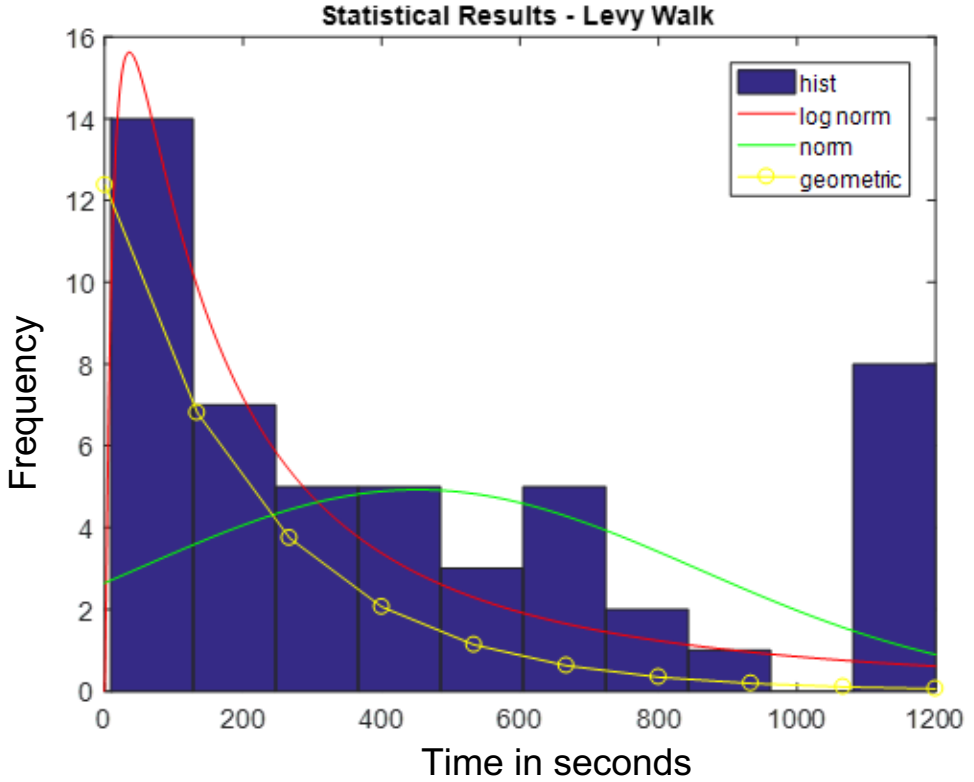
We looked at several distributions based on the outcome

onlinestatbook.com/2/introduction/distributions.html

Levy Walk Simulation Results

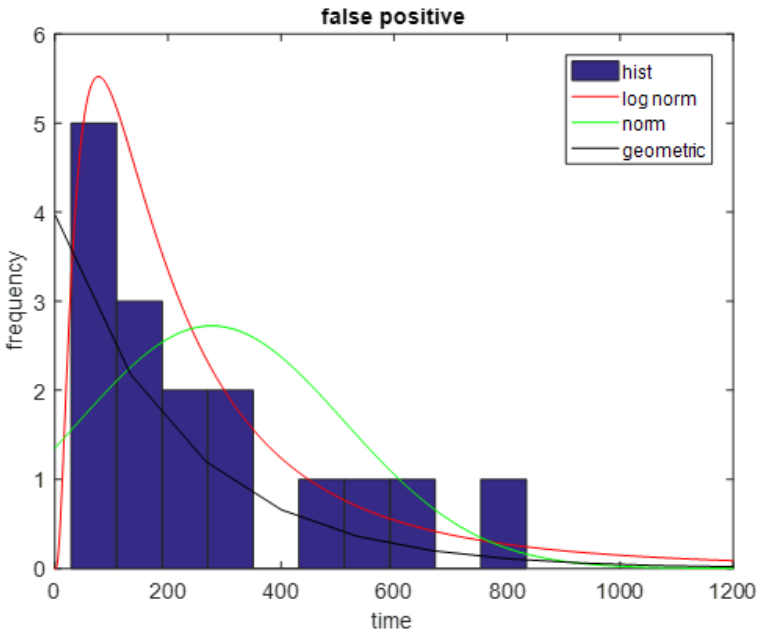
Statistical results

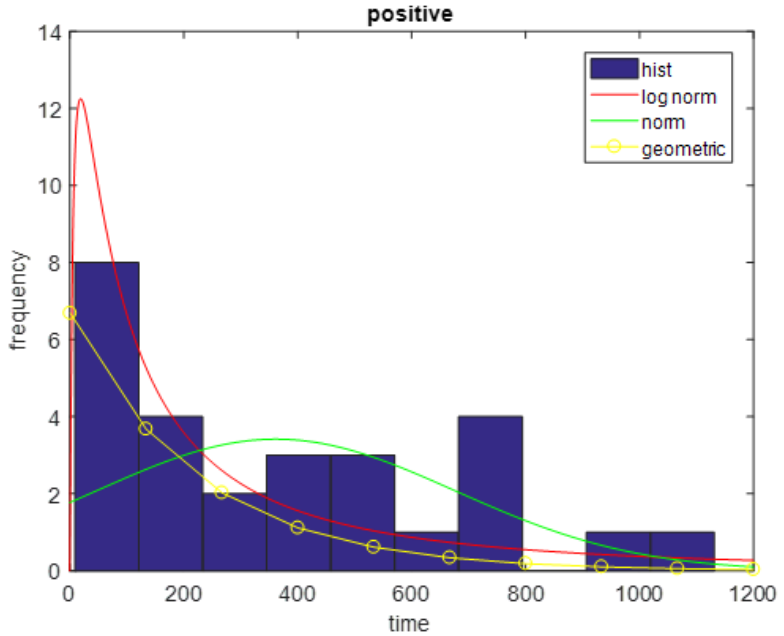
- Red line log normal distribution (μ=5.25, σ=0.952)
- Green line normal distribution (μ=277, σ=234)
- Yellow line geometric distribution (p=0.45)



Levy walk comparison positive & false positive

Statistical results

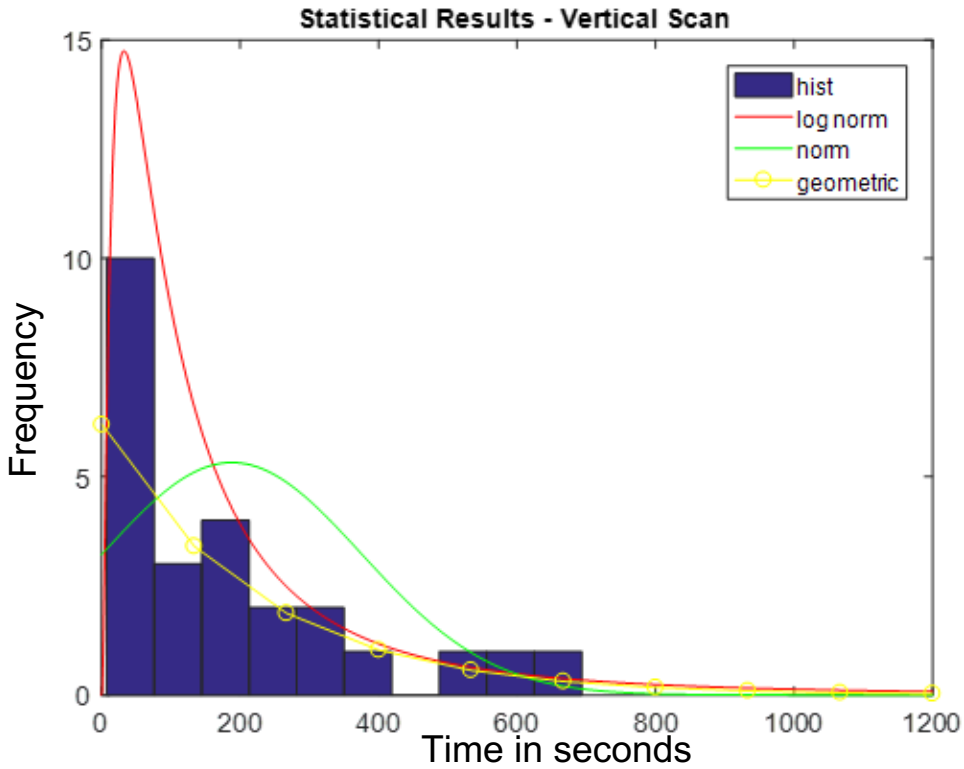




Vertical scanning simulation results

Statistical results

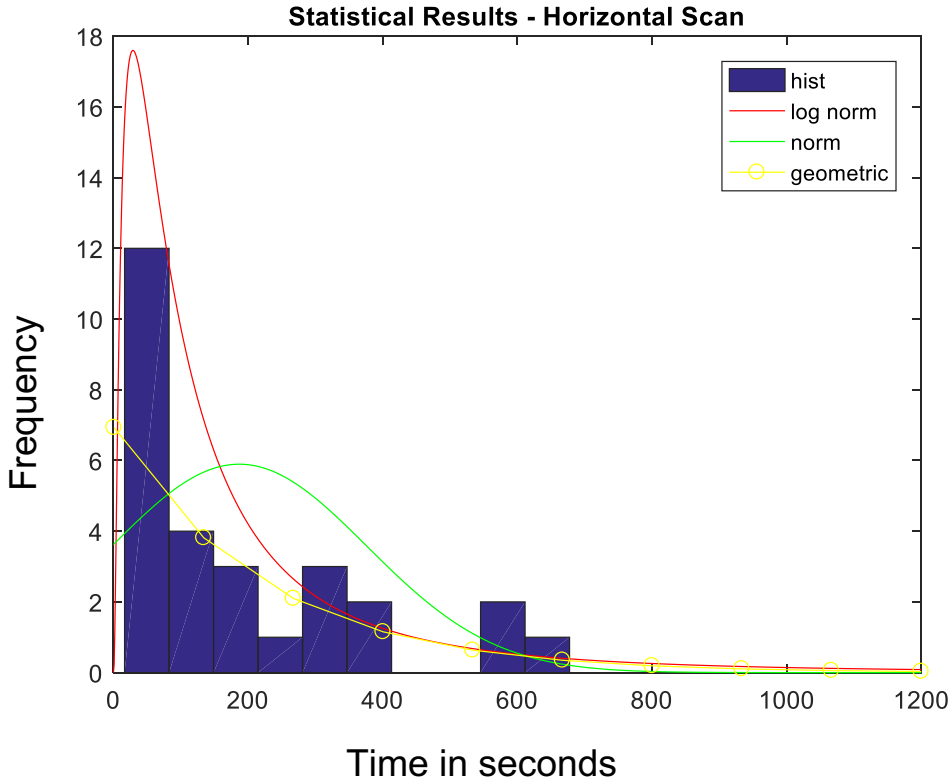
- Red line log normal distribution (μ=4.5, σ=1.12)
- Green line normal distribution (μ=155, σ=150)
- Yellow line geometric distribution (p=0.45)



Horizontal scanning simulation results

Show the statistical results

- Red line log normal distribution (μ=4.2, σ=0.998)
- Green line normal distribution (μ=108, σ=115)
- Yellow line geometric distribution (p=0.45)



Comparison of all simulation results

Best Odds

	Positive	Negative	False Positive	False Negative	Mean	Standard Deviation
Levy Walk	0.54	0.14	0.32	0	5.25	0.952
Total Scan	0.40	0	0.60	0	4.35	1.06
Vertical Scan	0.36	0	0.64	0	4.5	1.12
Horizontal Scan	0.43	0	0.57	0	4.2	0.998

Faster Detection Time

Conclusions and Future Work

Is scanning better than levy walks? Yes/No - we need more data

- Scanning - faster rates of detection and higher false detections
- Levy walk - slower rates of detection and higher positive detections
- Levy walk - also missed the target

How to move forward?

- See how flight time is affected by different map size
- Optimize workflow in compiled low-level language (MATLAB is proprietary and thus evil)
- Try multiple searchers

References

[1]	Carpin et al. Variable Resolution Search with Quadrotors: Theory and Practice. J. Field Robotics. Vo 30. p(685-710). 2013. web
[2]	Chase, A., et al. (2014). "Ancient Maya Regional Settlement and Inter-Site Analysis: The 2013 West-Central Belize LiDAR Survey." Remote Sensing 6(9): 8671.
[3]	Dekking, F. M. et al. A Modern Introduction to Probability and Statistics. London: Springer, 2005. Print.
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[5]	Hollenbeck, D. Justification for Airworthiness and Safety Assessment: Aero-RTF/Aero-M. Aug 5, 2016. Avail upon request
[6]	Pingel, Johanna and Nehemiah, Avinash, “Object Recognition: Deep Learning and Machine Learning for Computer Vision,” Mathworks (2016).
[7]	Viswanathan, G.. Analyzing levy walks in 2D and 3D. Ghandi Viswanathan’s Blog. Web. April 23, 2014 link

Thank You
Questions?