



UNITED STATES MILITARY ACADEMY  
**WEST POINT**



# **Game of Drones: Human-Machine Comparison in Simulated Drone Search Operations**

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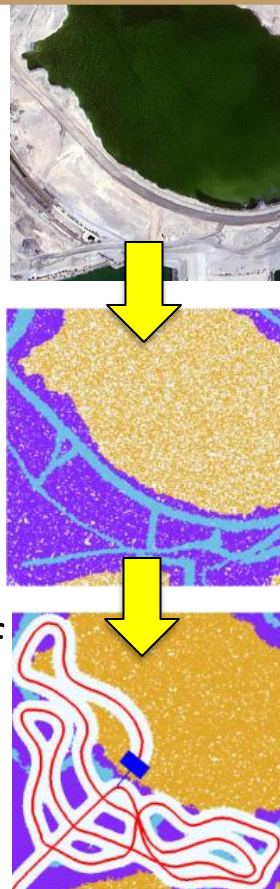
1. Background, Purpose, & Motivation of Research
2. Literature Review
3. Study Design
4. Data Collection
5. Evaluating Performance
6. Results
7. Conclusions



**PURPOSE:** *Determine to what extent untrained human operators underperform or outperform a USMA-developed drone autonomy algorithm for aerial search*

## Background:

- CDTs previously created autonomous, gravity simulation of aerial SAR w/ drone
  - Used terrain classification to score weights of target probabilities
- **Current study:** comparison of human performance to gravity



## Motivations:

- How is autonomy in drone operations useful?
- Are there strategies that humans use that the algorithm does not?
- How can the algorithm be improved?

Figure 1: Classification of Aerial Image & Demonstration



## Performance of Multiple UAVs in Autonomous SAR Simulation

Andrade, Fabio A. A. et al. (Sensors, 2019)

- Measure time to amass 50% of PDF (w/ particle swarm optimization)
- 1-3 UAVS comparison → multiple UAVs performed better
- **Possible next step in study**

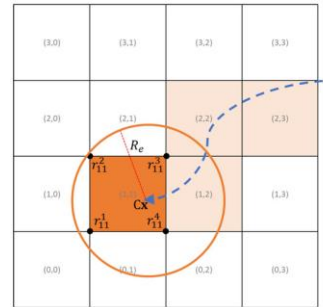


Figure 2: Probability assignment & amassing

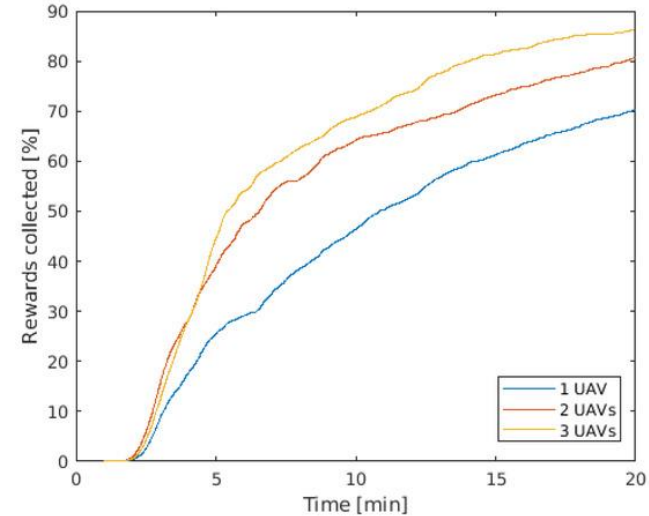


Figure 3: CDF of Multiple UAVS (Andrade et al.)

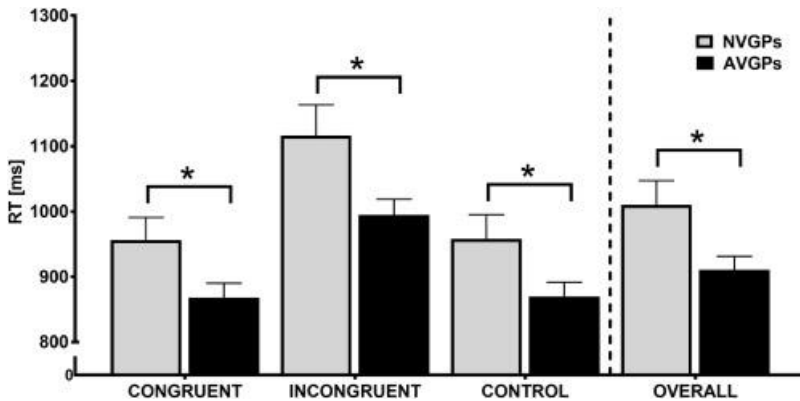


Figure 4: Reaction Time between Players (Kowal et al.)

## Cognitive Comparison Between Gamers and Non-Gamers

Kowal, Magdalena et al. (Computers in Human Behavior, 2018)

- Action video game players show better processing speeds but worse attentional inhibition
- **Will examine gaming experience**



## Power Analysis (using pilot data):

Effect Size: 0.488627; **n = 67**

Effect Size: 0.318392; **n = 156**

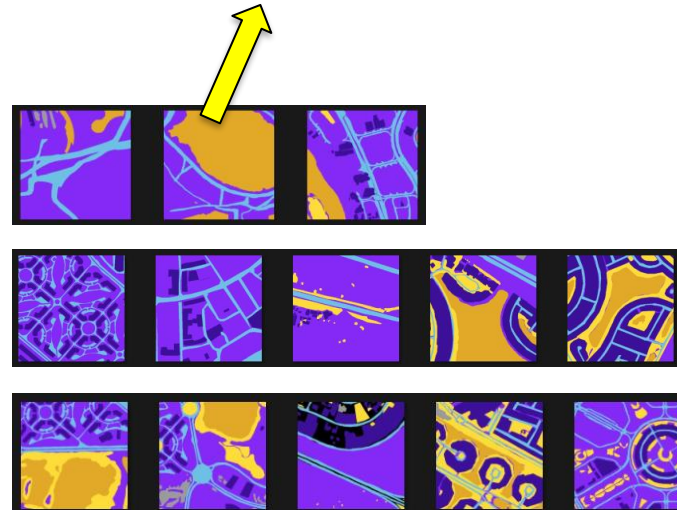
$$N = \frac{(r + 1)(Z_{\alpha/2} + Z_{1-\beta})^2 \sigma^2}{rd^2}$$

	machine	mean_group	sd_group	n
1	Gravity	632.8676	37.73183	5
2	Lawnmower	689.2127	127.83562	5
3	Spiral	723.6028	56.42089	5
4	human	653.4866	66.19424	60

Table 1: Power Analysis

Study consisted of 2 rounds, in addition to a tutorial

Modifications to original application included progress bar, turn controls, and user interface



**TUTORIAL**

**ROUND 1**

**ROUND 2**

Figure 5: Selected Tiles for Study



Data collected from **221 participants** over the course of 7 sessions.

Each participant played 10 “tiles” (aerial images)



Figure 7: Participants instructed to use a mouse, but some used the track pad instead



Figure 6: Level of excitement varied across participants

Data recorded along with their academic major, drone experience, and video game experience



The **Area Above the CDF (AAC)** measures the expected time to mission completion.

$$E[T_{\mathcal{P}}] = \int_0^{F_T^{-1}(\mathcal{P})} (\mathcal{P} - F_T(t)) dt$$

Lower AAC = Better Performance

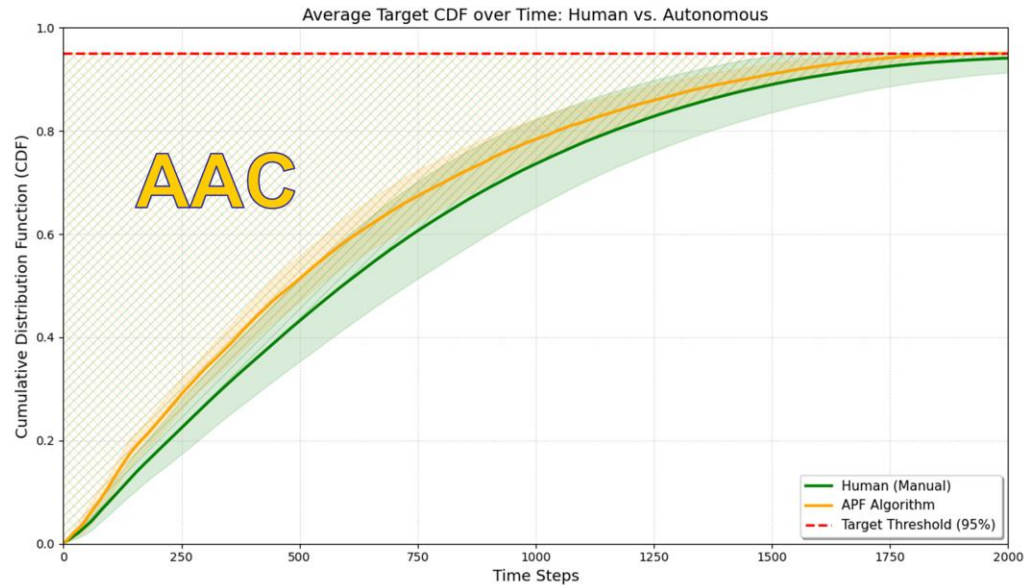


Figure 8: Average CDF by Algorithm (Target = Automobile)



The gravity algorithm **outperformed** all but 8 human participants, but comparative performance differed across tiles.

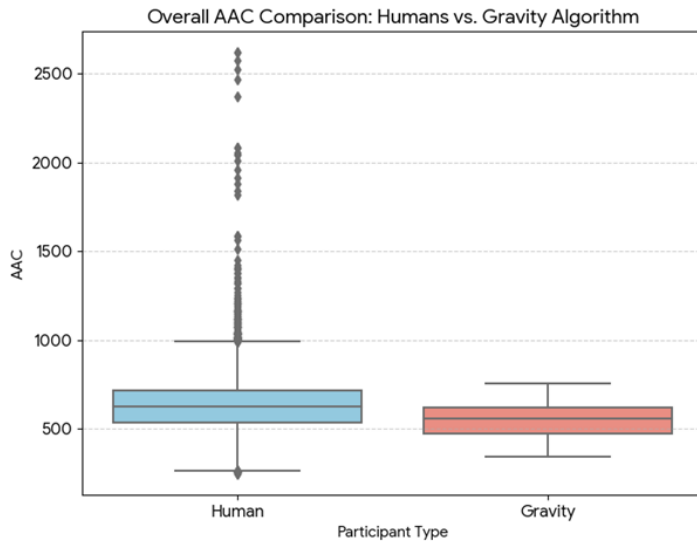


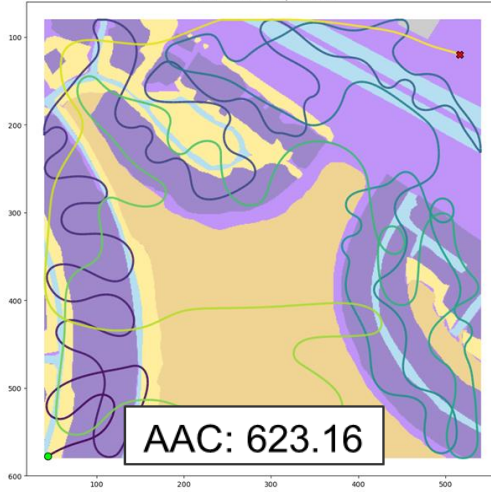
Figure 9: Overall AAC Comparison

**Human Mean AAC: 717.47**  
**Autonomous Mean AAC: 622.01**  
**T-statistic: 15.96   p-value: 9.82 \* e-35**

The autonomous algorithm **defeats** humans within the interval of **[83.42, 107.50] (95% CI)**



User: DeltaFourPlebeR | Terrain: 136



Gravity Run | Terrain: 136

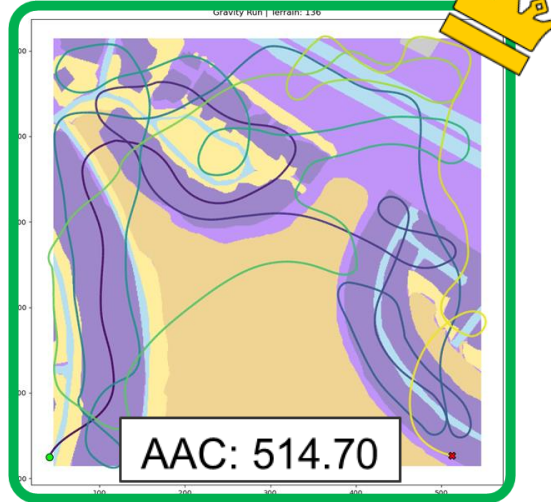
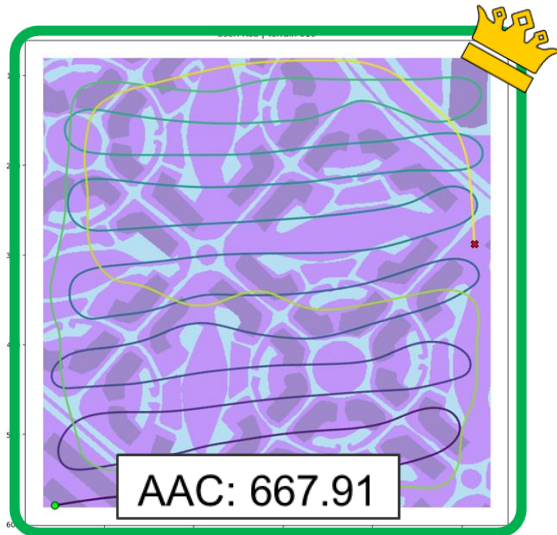


Figure 10: median performing human (left) compared to APF (right) for Image 136

Gravity Run | Terrain: 010



Gravity Run | Terrain: 010

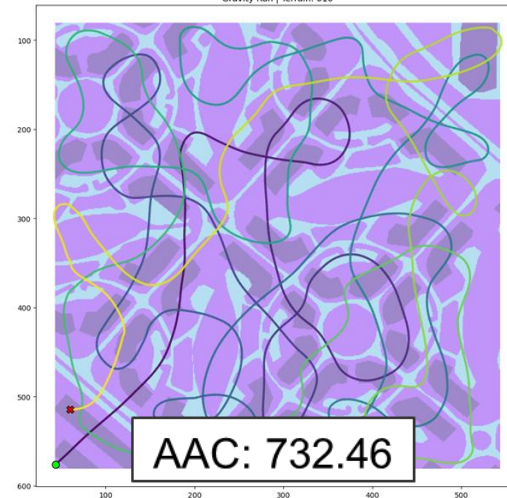
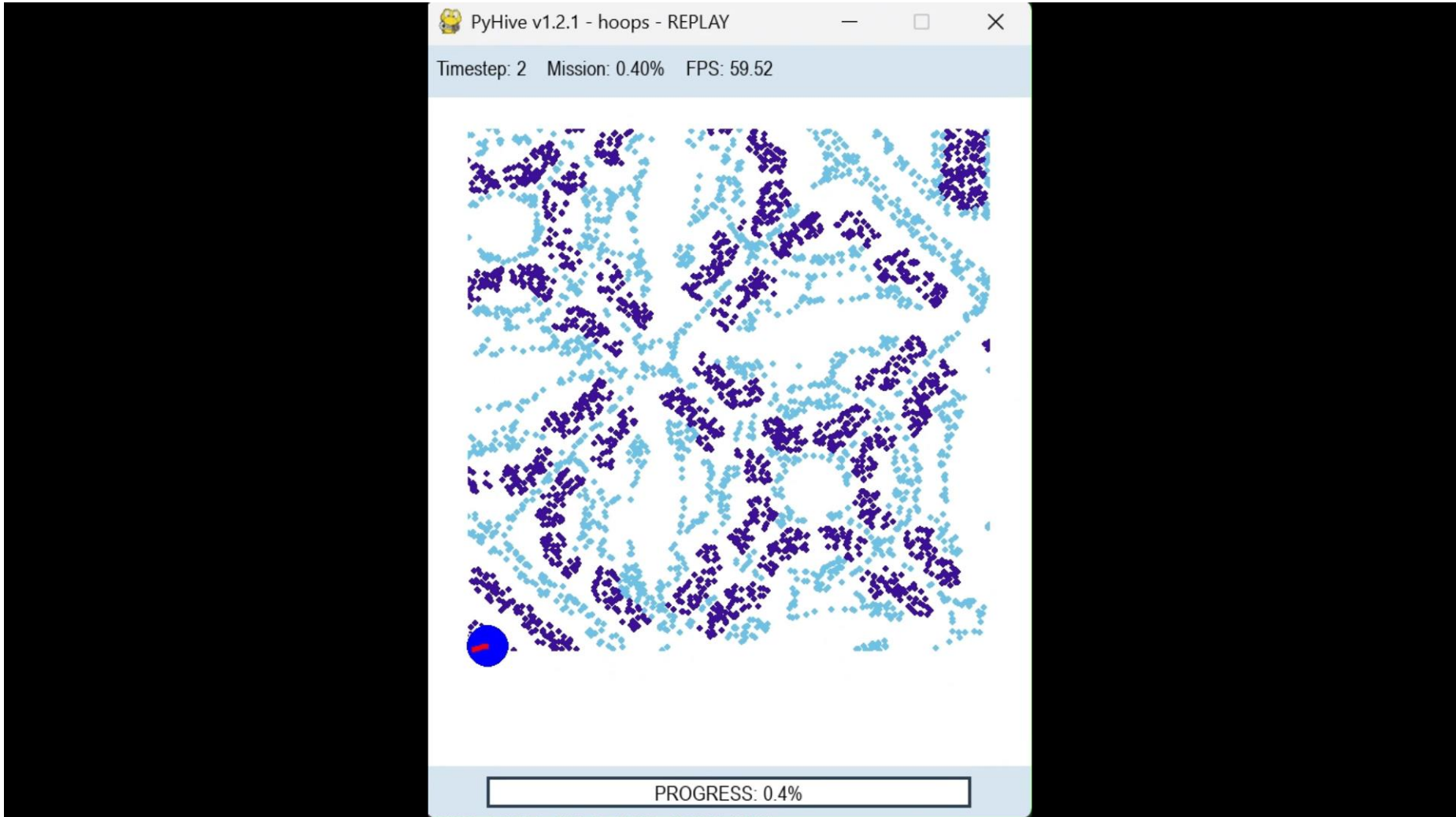


Figure 11: : high performing human (left) compared to APF (right) for Image 010

**A large proportion of water in the image benefits the algorithm's probabilistic pathfinding.**

**Humans perform better in dense, urban areas with lower probabilistic variance.**





**APF outpaces manual steering** in varied landscapes.

Both methods achieve high performance in **in regions with a contiguous body of water.**

Human superiority in urban areas identifies a **key algorithmic weakness** for future development.



### Future Works:

Multi-drone swarm comparison

Fitting distributions to AAC

Simulation to real-world validation

Sampling of professional, certified drone pilots