

Prior knowledge based search and rescue

Nicholas C Manoukis¹, Sachit Butail², Derek A. Paley², Alpha S Yaro³, Moussa Diallo³, Sékou F Traoré³, Adama Dao³, José MC Ribeiro¹, Tovi Lehmann¹

¹Laboratory of Malaria and Vector Research, NIAID/NIH, ²Department of Aerospace Engineering, University of Maryland, College Park, ³Malaria Research and Training Center (MRTC), Faculté de Médecine, de Pharmacie et d'Odontostomatologie, Université de Bamako, Mali

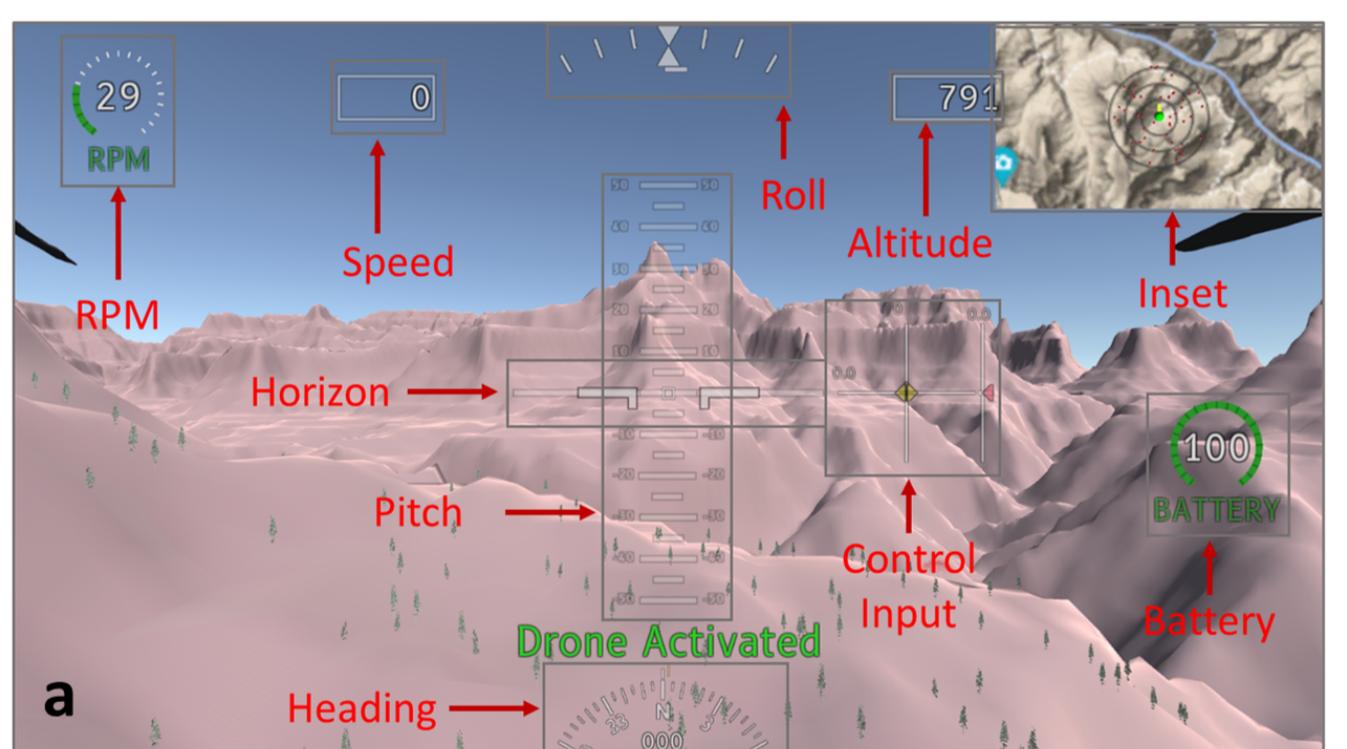
Objective

In search and rescue (SAR) missions search areas grow geometrically with time. Compared to ground-based search, teleoperated unmanned aerial vehicles (UAVs) play an important role in SAR efforts as they cover large areas in relatively less time. At the same time, teleoperated UAVs may not scale with the size of the region to be covered-assistance to the UAV teleoperator may be provided in the form of autonomous UAVs searching alongside. Such an assistance should be robust, responsive to differences in knowledge, workload, and situational awareness, and not rely on transmitting sensitive data through a large bandwidth.

Hypotheses

- ▶ Prior knowledge of terrain or missing person
- ▶ Cognitive load of a teleoperator
- ▶ Situational awareness of the teleoperator

Virtual Replica of Grand Canyon



View of the virtual environment through a drone camera (a) and model of the missing person (b).

- ▶ Virtual environment is a replica of a $10 \text{ km} \times 10 \text{ km}$ of Grand Canyon National Park
- ▶ The environment was built in Unity software, using terrain data generated from an online height map generator.
- ▶ The operator controls a first person view virtual quad-copter, with important information like altitude, GPS position and battery level projected on the head up display.

Cognitive Load

Mental effort exerted during performance of a task stressing the working memory is known as cognitive load. Cognitive load can be estimated in various ways:

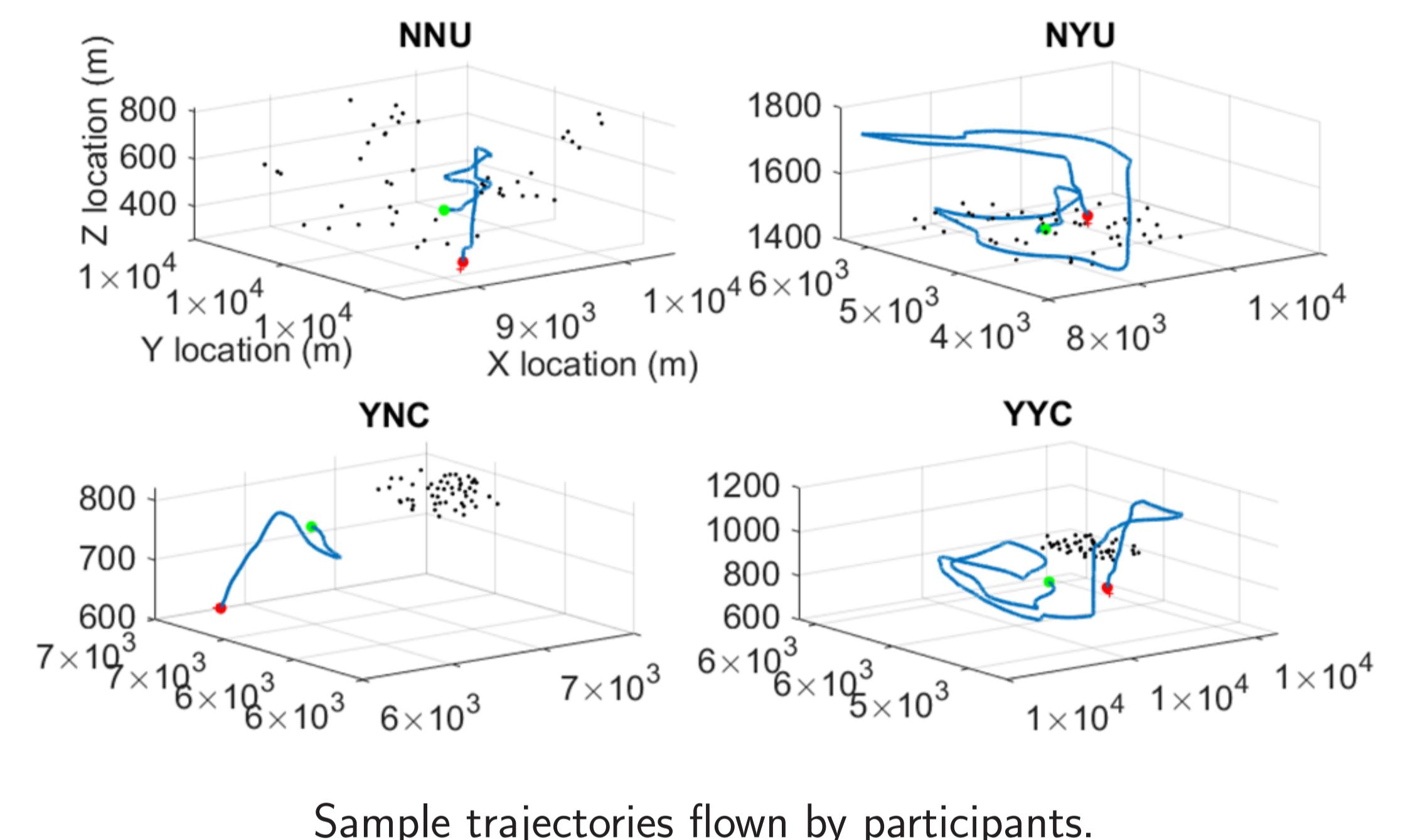
- ▶ Using Electroencephalography (EEG) by measuring the difference in α -power between a baseline period and performance of a task.
- ▶ Using saccade frequency from an eye-tracker, which is defined as fast movement of eyes between fixations.
- ▶ Using pupil dilation.

Situational Awareness

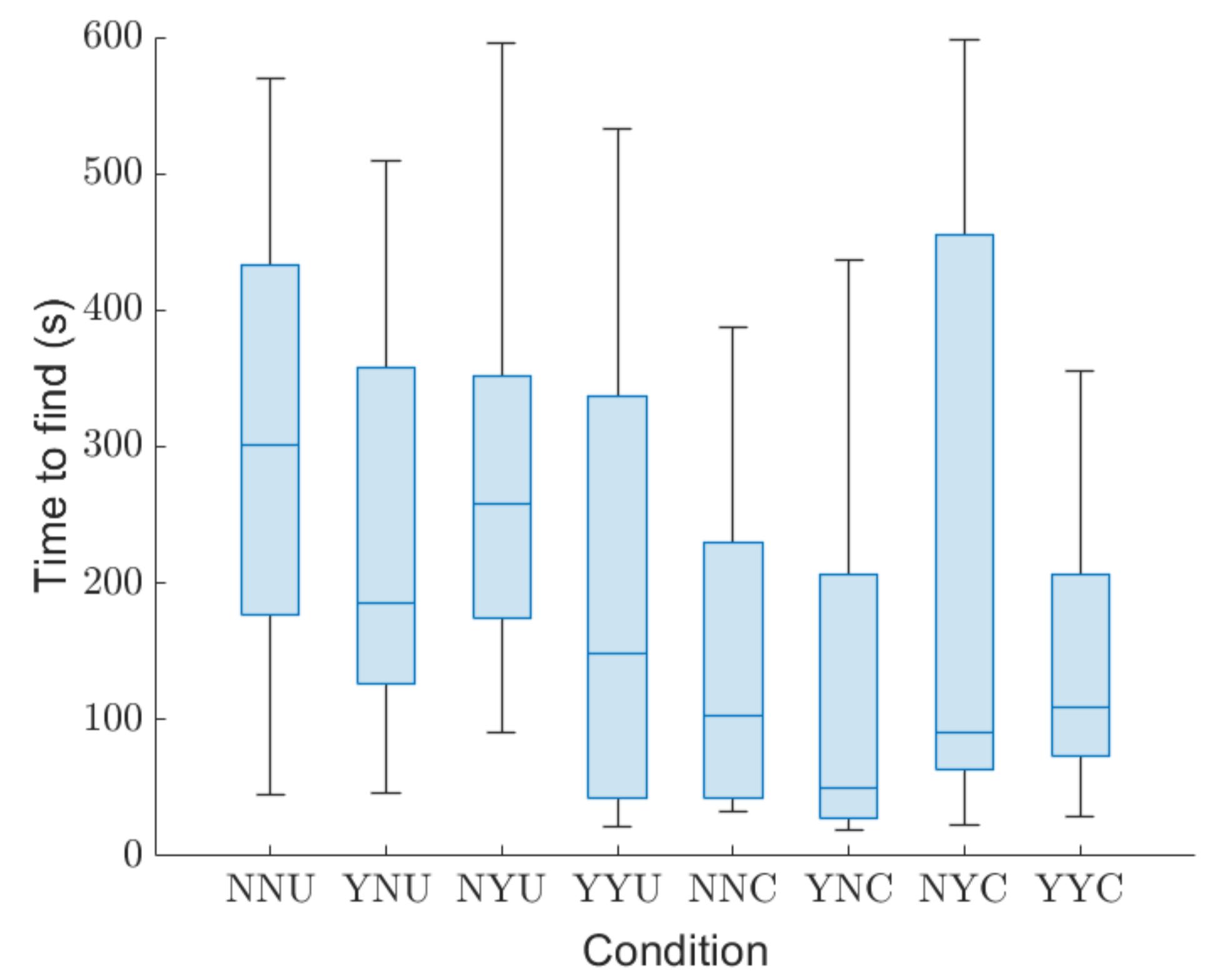
Situational awareness refers to the ability to perceive, comprehend, and anticipate elements in the environment that are critical for decision-making and effective action.

- ▶ Level 1: The perception of the environment using sense organs.
- ▶ Level 2: Synthesis of information gathered from level 1 SA, for example pattern recognition.
- ▶ Level 3: Ability to project the status of the environment and elements within it in the future, i.e. ability to predict.

Experimental results



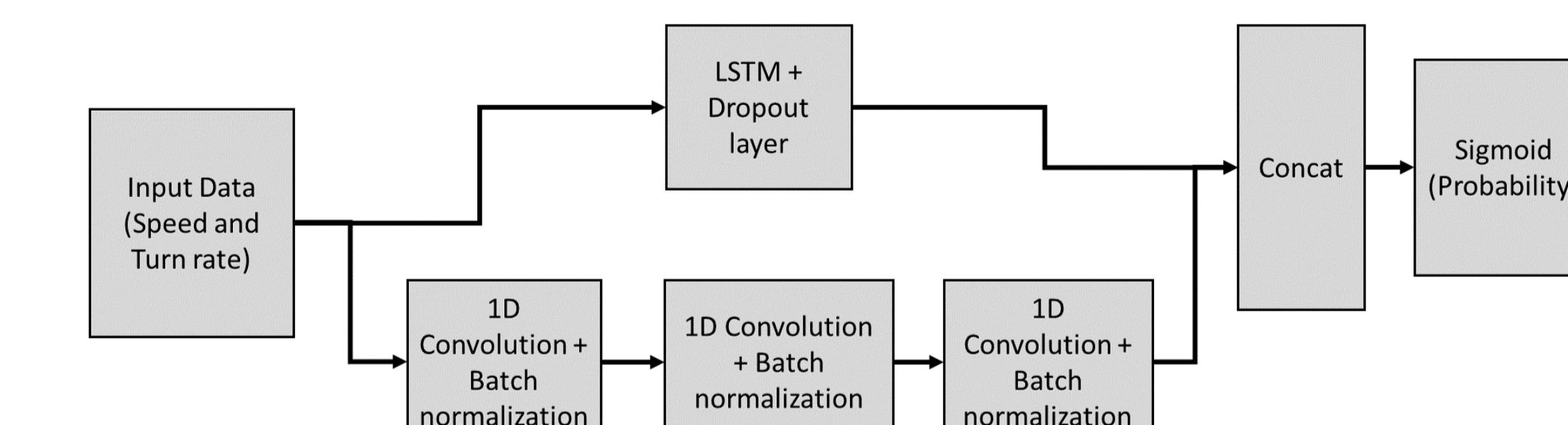
Sample trajectories flown by participants.



Performance of participants based on condition.

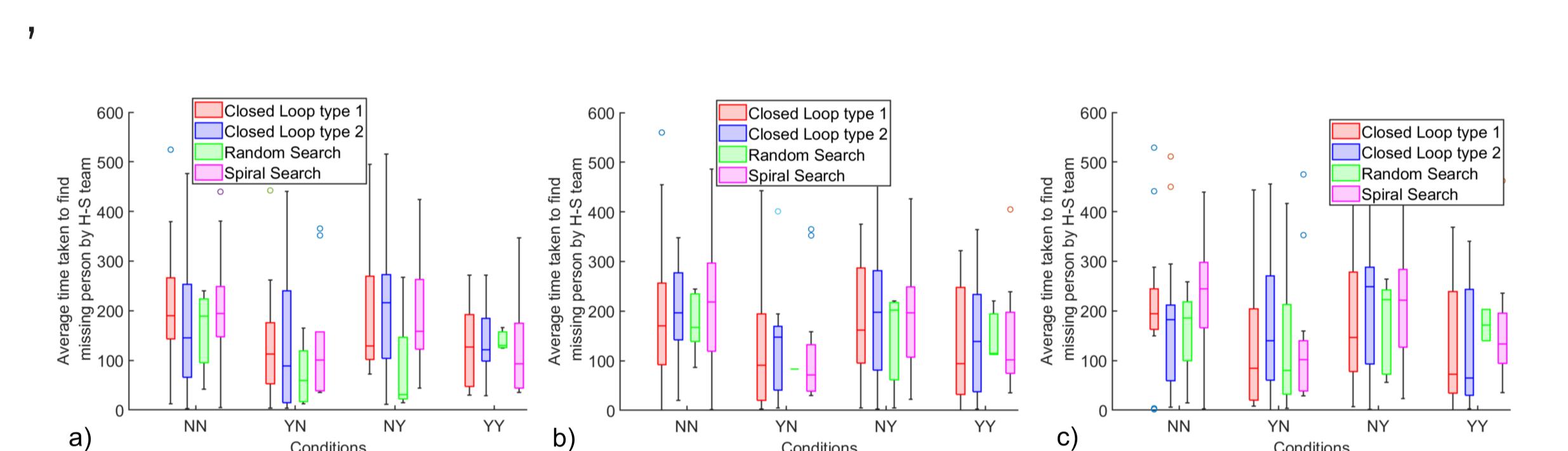
- ▶ Average performance of participants is higher for clustered swarm.

LSTM to classify prior knowledge

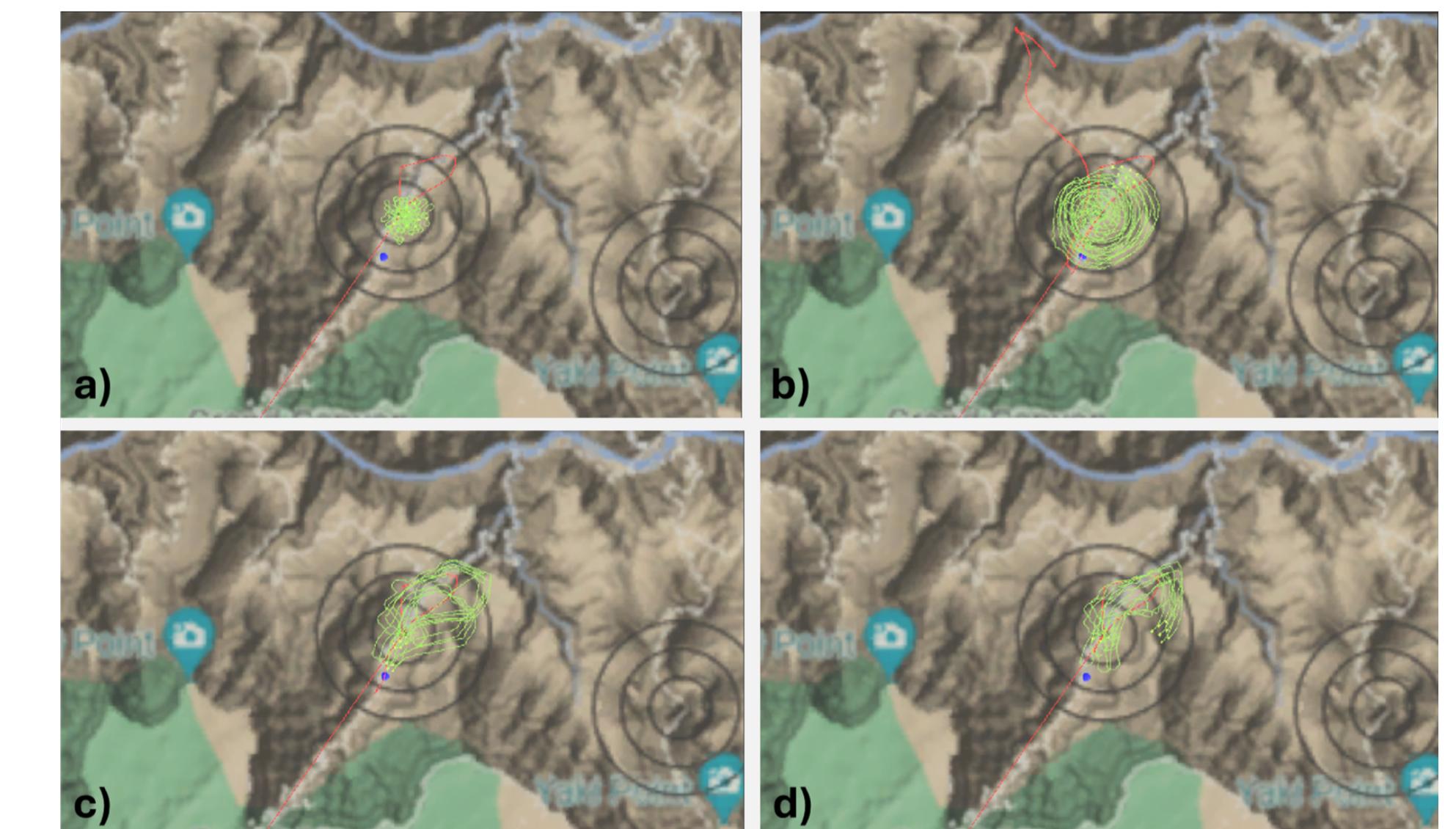


The neural network architecture used to train prior knowledge inference model.

Simulation Results



Average time to find missing person using swarm size of a) 5, b) 10, and, c) 15.



Trajectory of the autonomous swarm in a) Random search, b) Spiral search, c) Closed loop type 1, and d) Closed loop type 2 search.

Conclusion

- ▶ Unprecedented data on mating dance of *An. gambiae*
- ▶ Focal male may be special: ability to accelerate, position within swarm
- ▶ Pursuit analysis points towards a hypothesis that female may be following male

Acknowledgements: Thanks to the residents of Doneguebougou for allowing us to film.