The Application of Clustering Analysis in the Assessment of Eye Movements during Flight Training Intervention

Capstone Project

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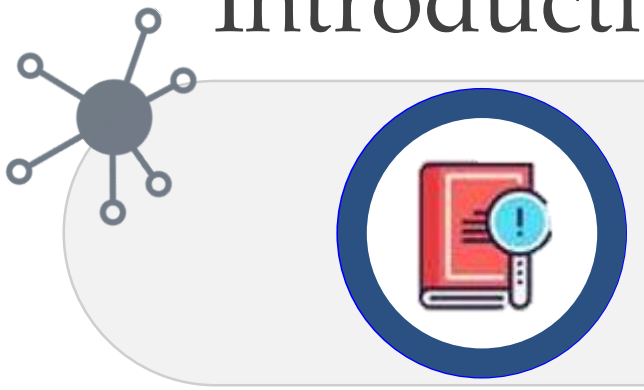
Introduction



Intro to Training Intervention

Major goals of a training intervention:

- **Novice pilots and experts pilots apply different scanning pattern**
  - **Experts have structure scanning pattern,**
  - **Novice, on the other end, have random scanning pattern**

Intro to Training Intervention

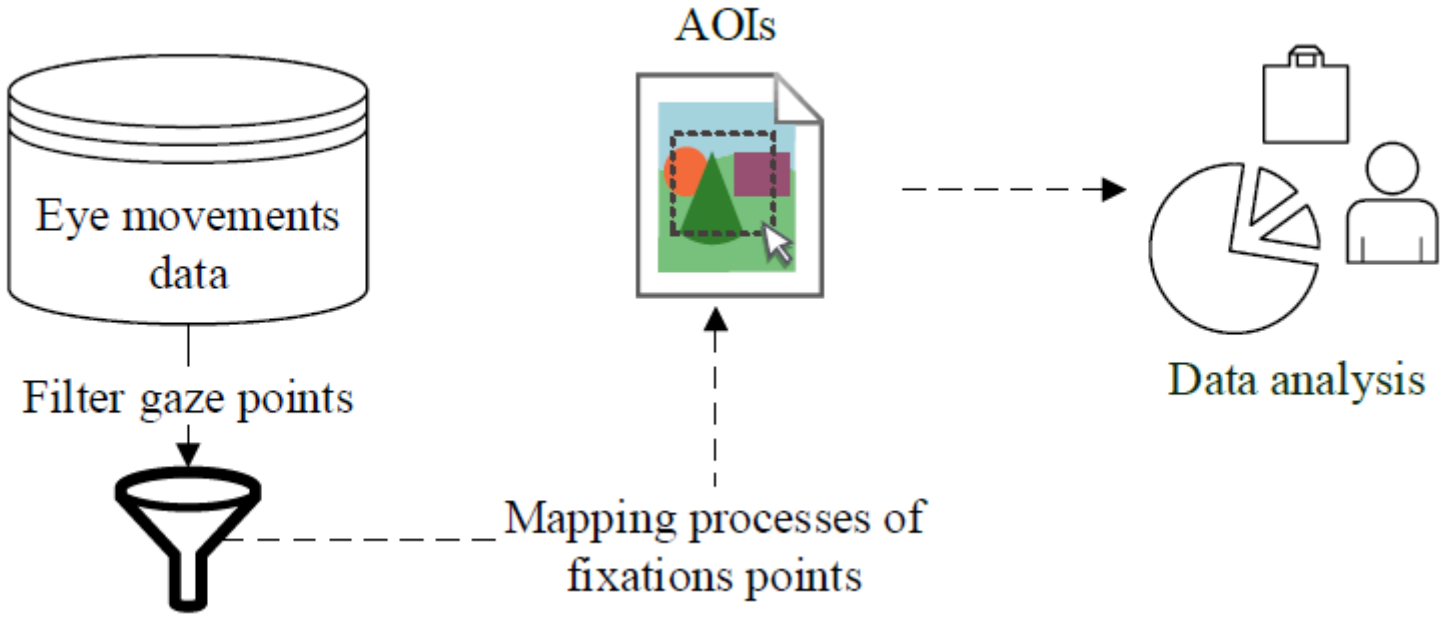
How improve pilots scanning pattern

- **Pilots could be trained on tactical scanning using an eye tracking technology and a flight simulator**

There are some metrics to compare novices scanning pattern with experts, but …

Intro to Training Intervention

Analysis of eye movements data is a time-consuming task



In automatic mapping process by software is not enough accurate, so manual mapping is a must !

Intro to Training Intervention

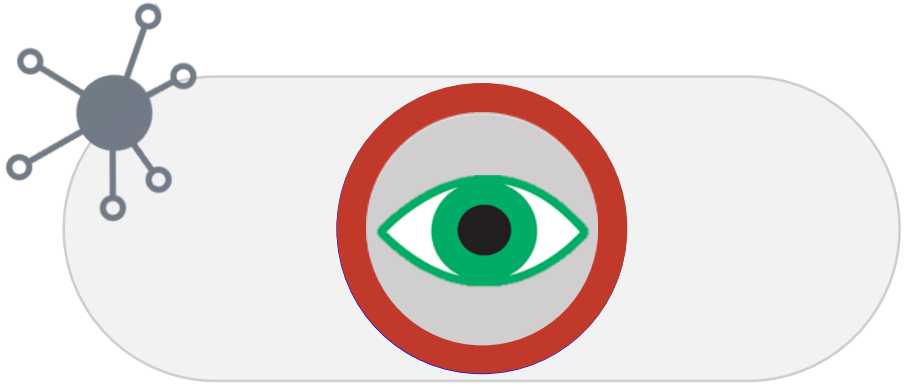
What could be done?

Focusing on gaze points rather than fixation points

- **Gaze points are raw data before mapping on Areas of Interests (AOIs)**
- **Fixation point provides insight on people look points using Areas of Interests (AOIs).**

So, maybe gaze points could shed light on peoples eye movements.

Methodology



Participants

Twenty **novice pilots** are selected from student pilots with no IFR training.

- Pilots were divided into experimental and control group.
  - Three pilots of experimental group and three pilots from control group did the experiment, in addition to one expert pilots

Apparatus

Eye Tracker

- Tobii Pro Glasses 2 is a lightweight, head-mou

- **Sampling Frequency**

  60 Hz

Eye tracker collects eye movements data such as gaze point, fixation point, fixation duration & …

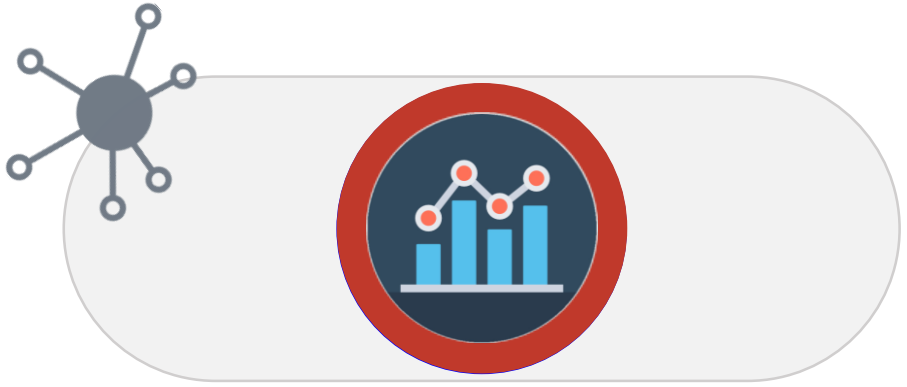
Apparatus

Flight simulator

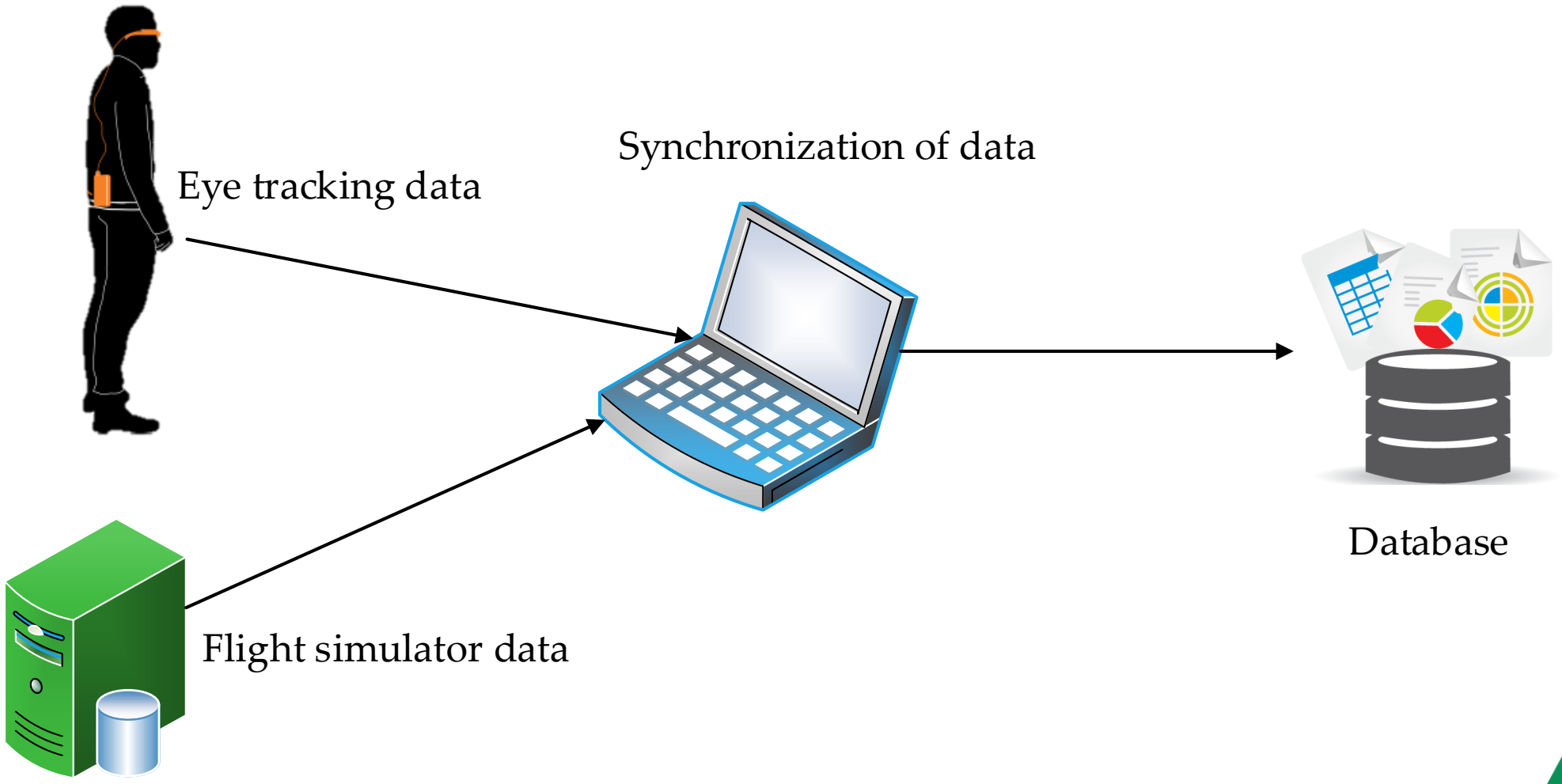
- **Software:** X-Plane 11
- **Hardware:** simulator frame and seat, simulator
  controls
- **Sampling Frequency**
  60 Hz

Flight simulator collects flight data such as altitude, airspeed, heading & …

Data Analysis



Procedure for Data Collection



Eye movement Metrics

Shannon Entropy

$$H(X) = -\sum_{i=1}^{N} P(x_i) \log_2 P(x_i)$$

- It is a metric that indict to visual search.
- The unit is bit.
- Higher value shows the tendency of participants:
  - to look at various objects
  - to the randomness of scanning pattern
- Lower value indicate the fact participants narrowed visual attentions & had a more structured scanning pattern

Eye movement Metrics

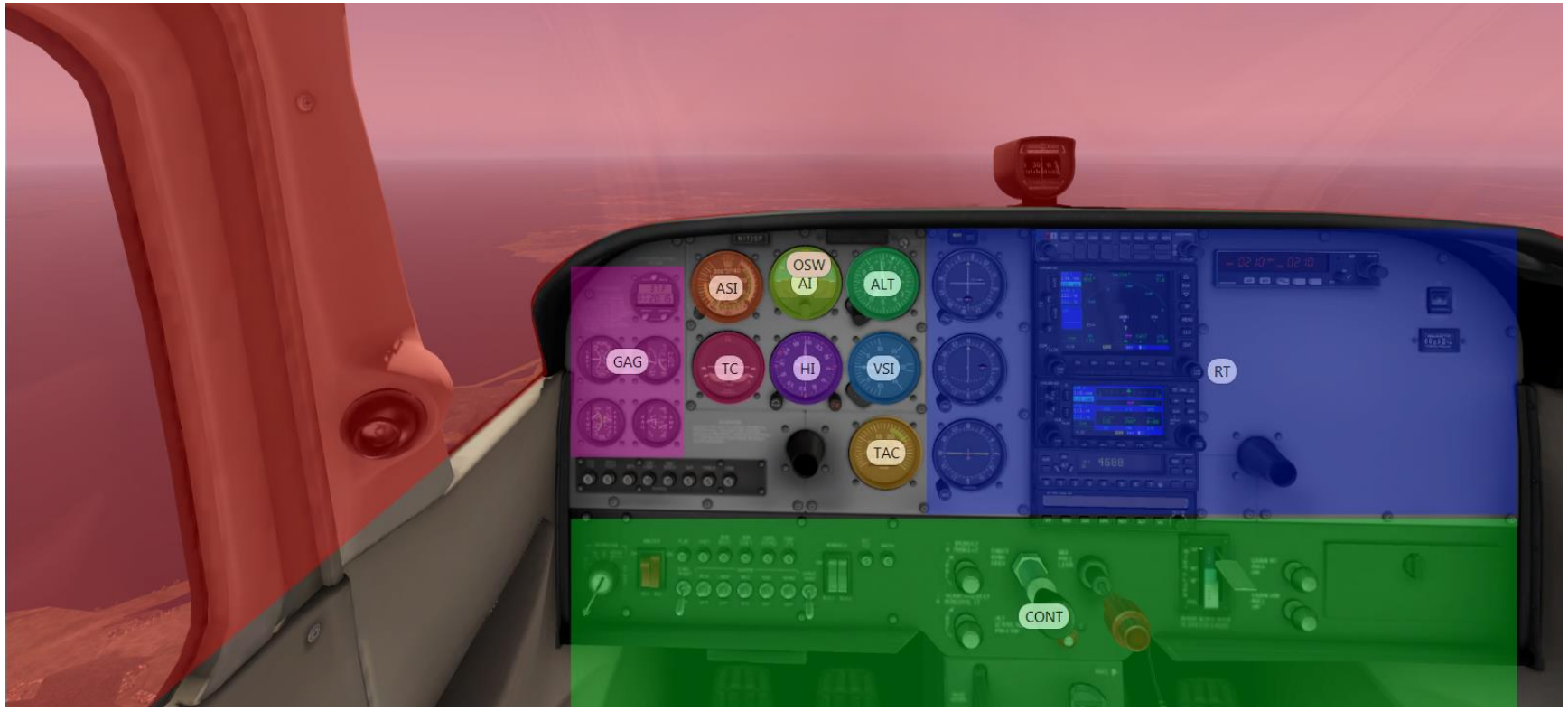
Shannon Entropy

$$H(X) = -\sum_{i=1}^{N} P(x_i) \log_2 P(x_i)$$

- How compute it?
  - First, constructing of eye movements transition matric
  - Then, computing probability of each transition
  - Finally, calculating visual entropy using Shannon Entropy equation.

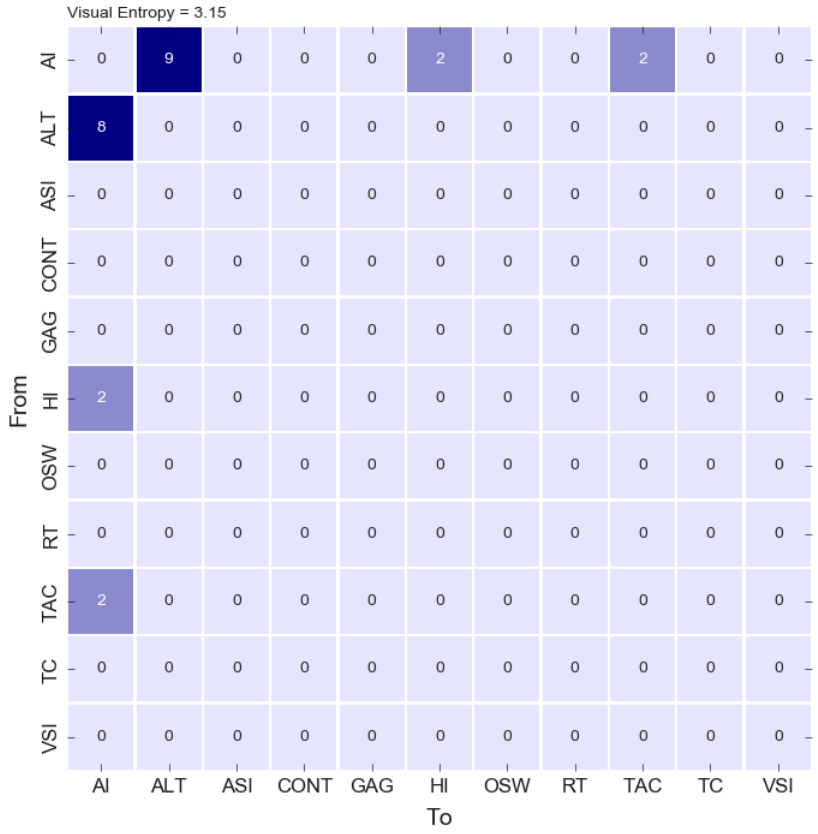
Flight Environment

- Flight environment were divided into 11 AOIs



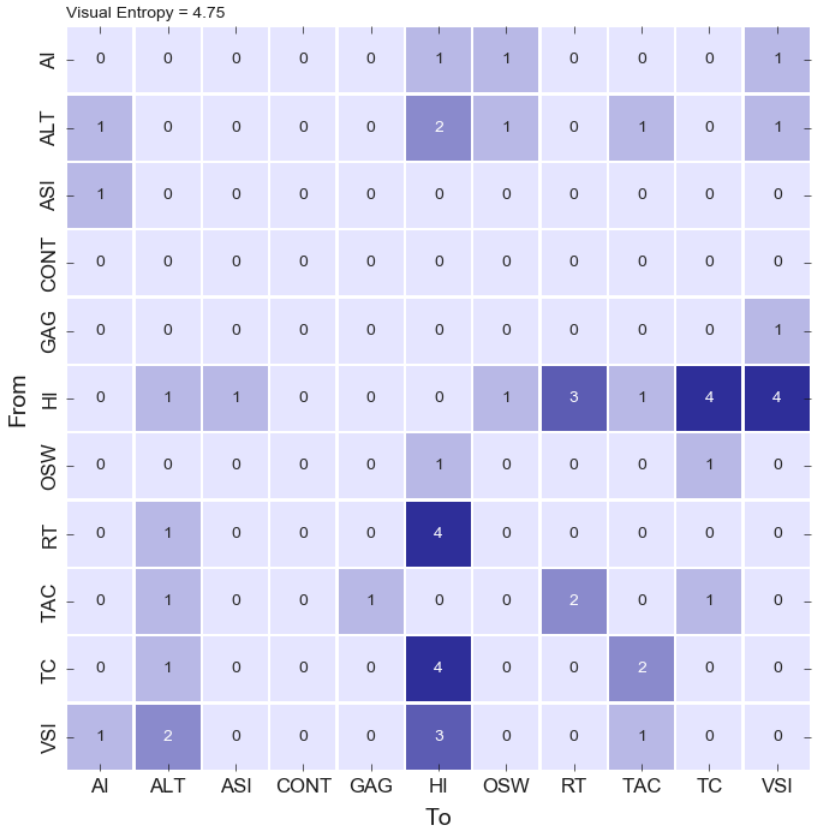
Flight Environment and Visual Entropy

Structured scanning pattern



Entropy: 3.15 bits

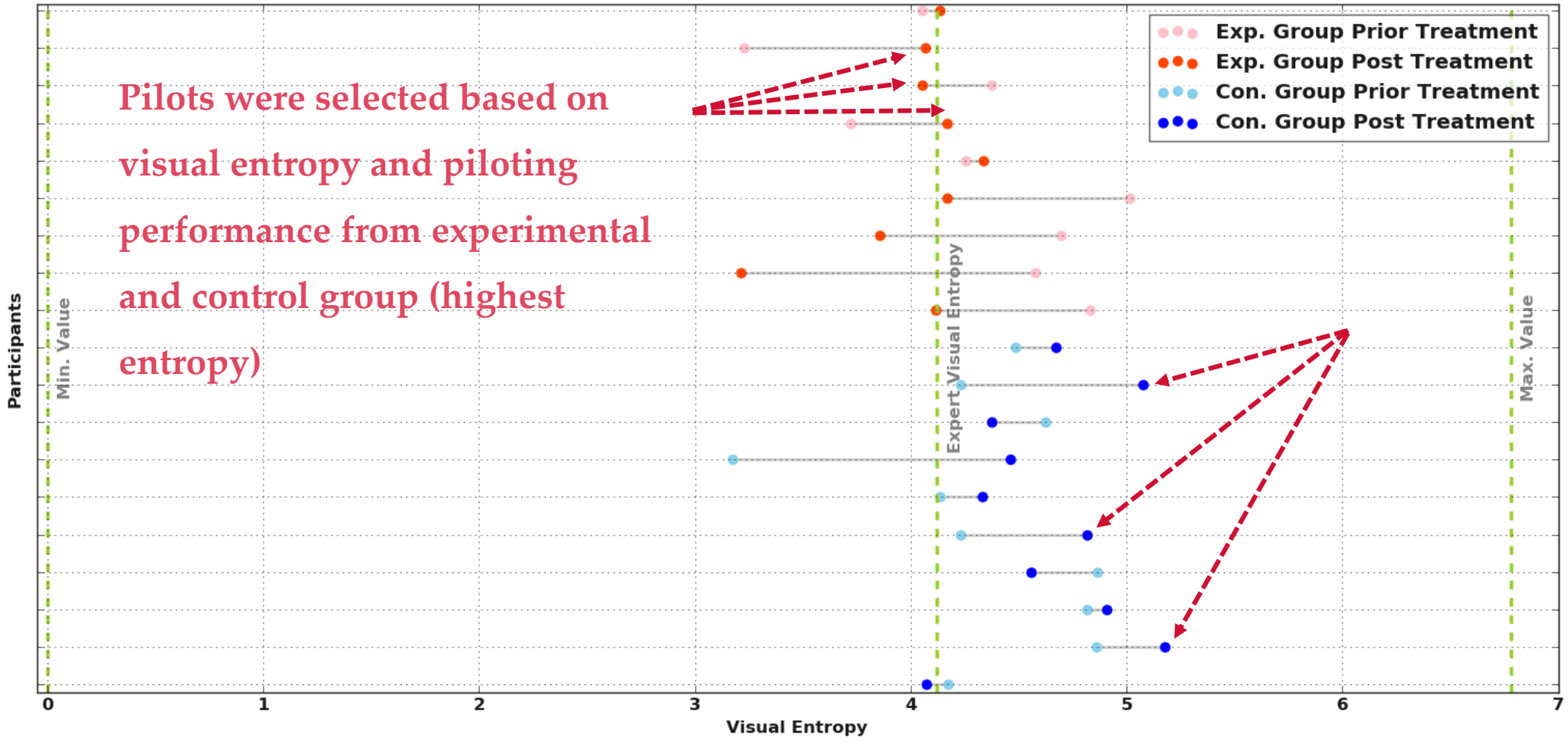
Random scanning pattern



Entropy: 4.75 bits

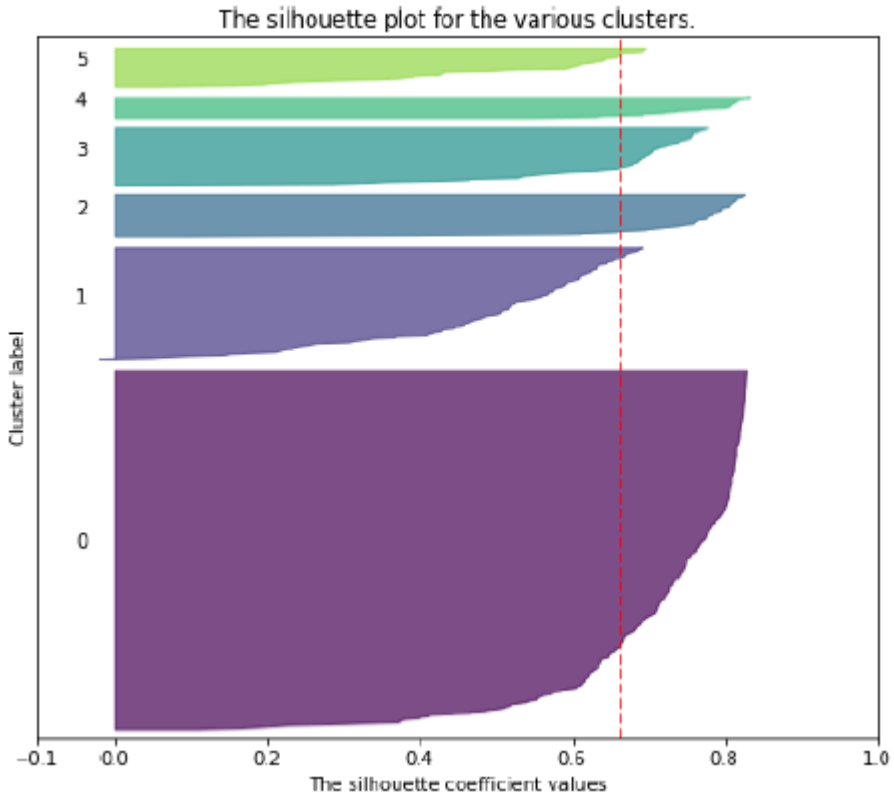
How pilots were selected from research group?

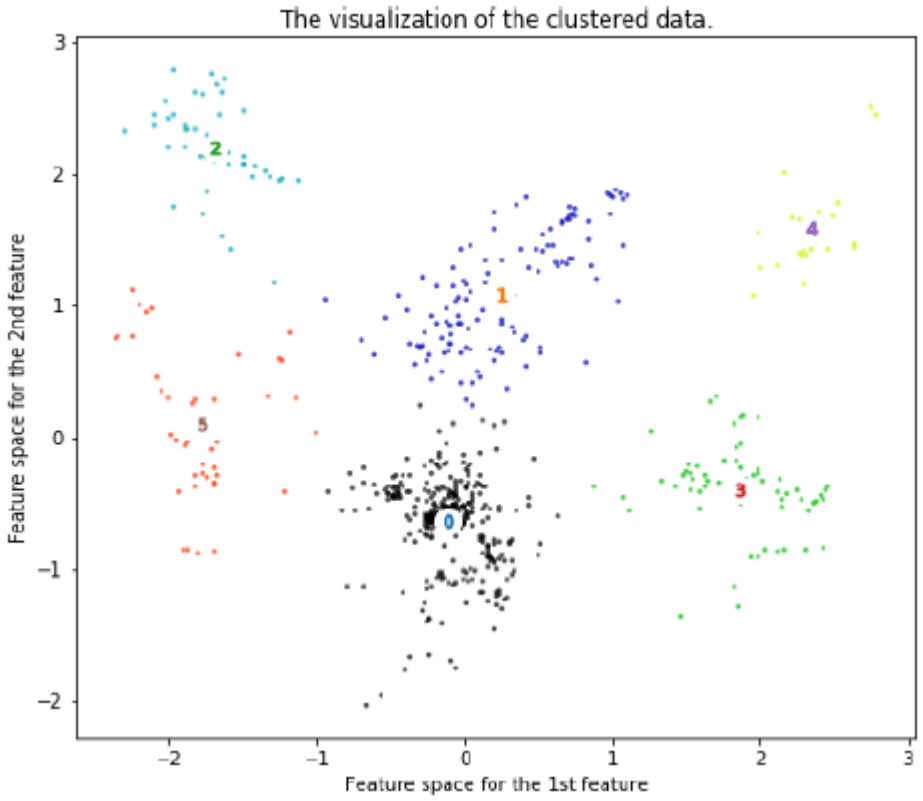
Pilots were selected based on visual entropy and piloting performance from experimental and control group (highest entropy)



Clustering analysis on gaze points

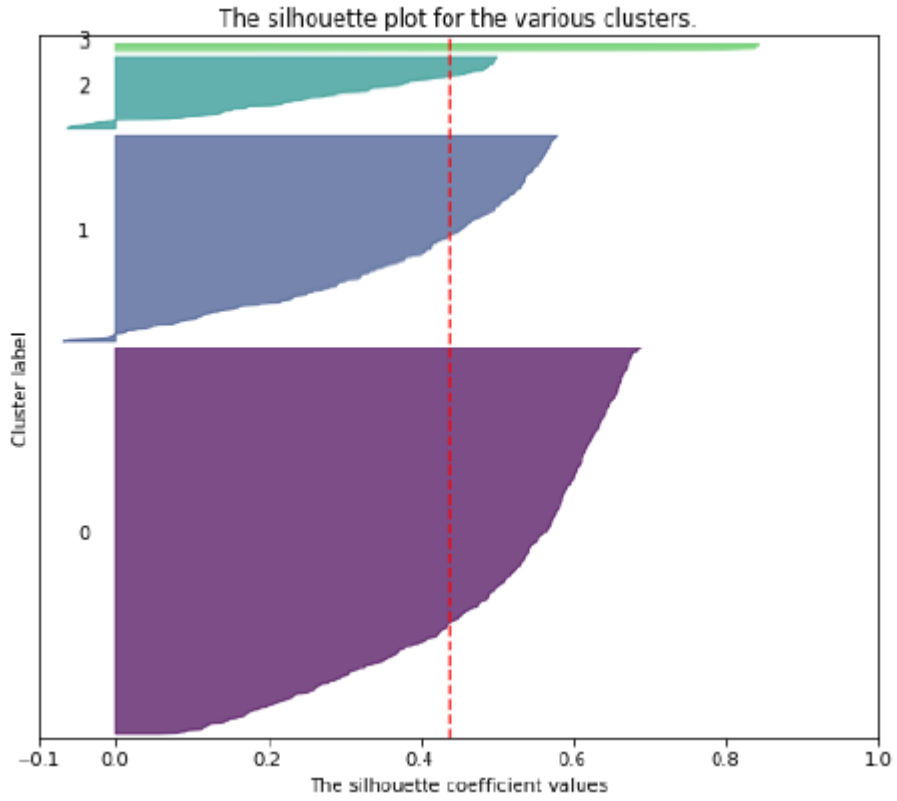
Expert pilot

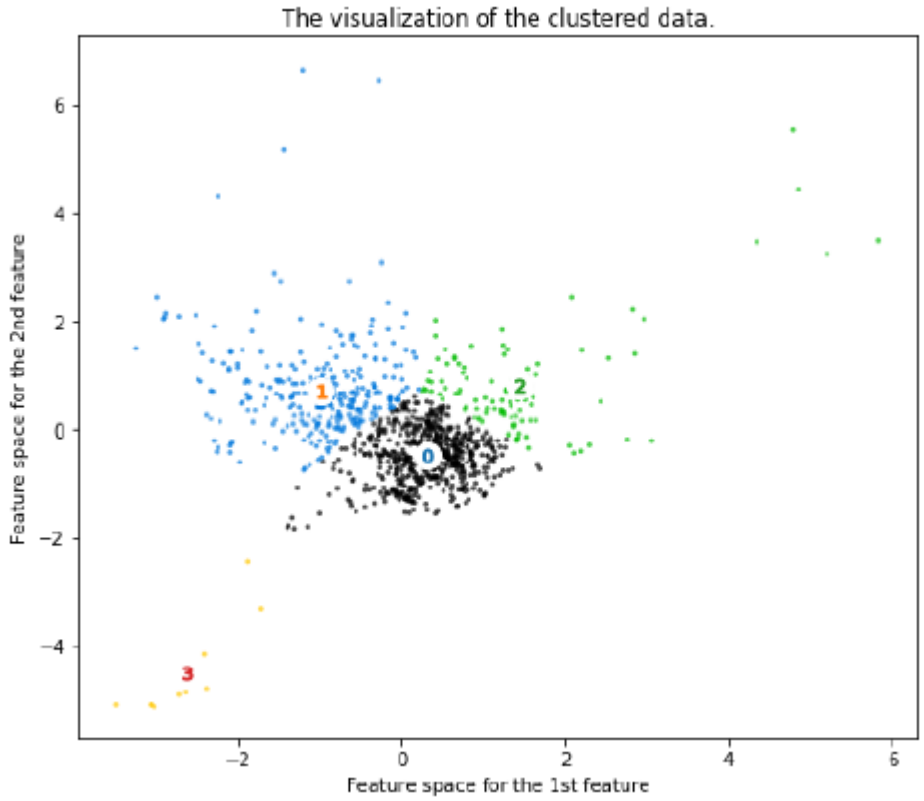




Clustering analysis on gaze points

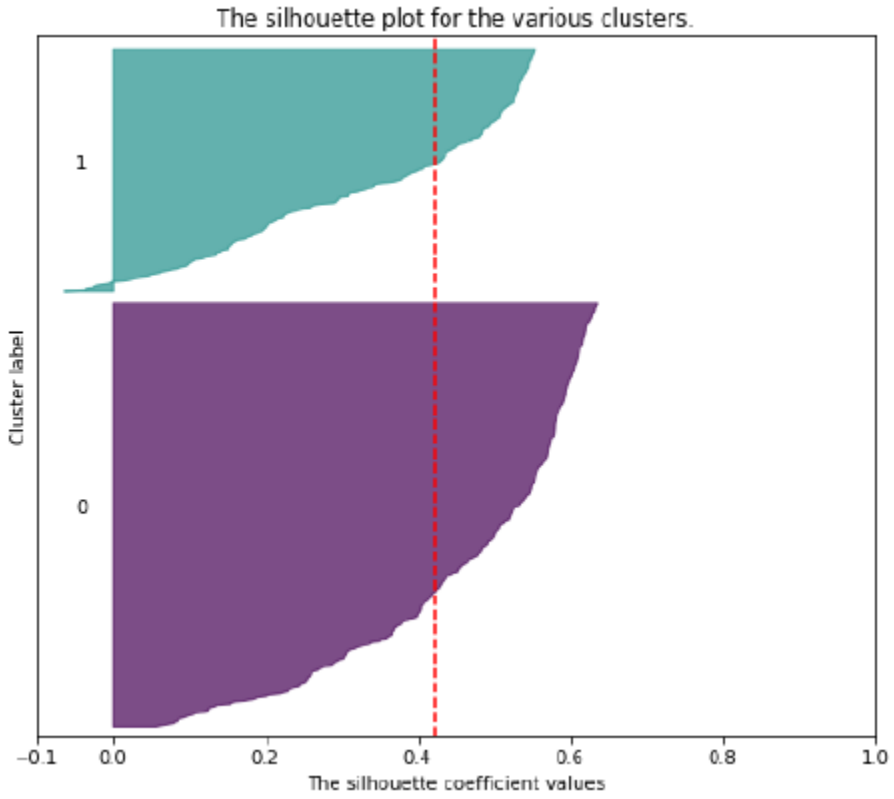
Pilots from experimental group

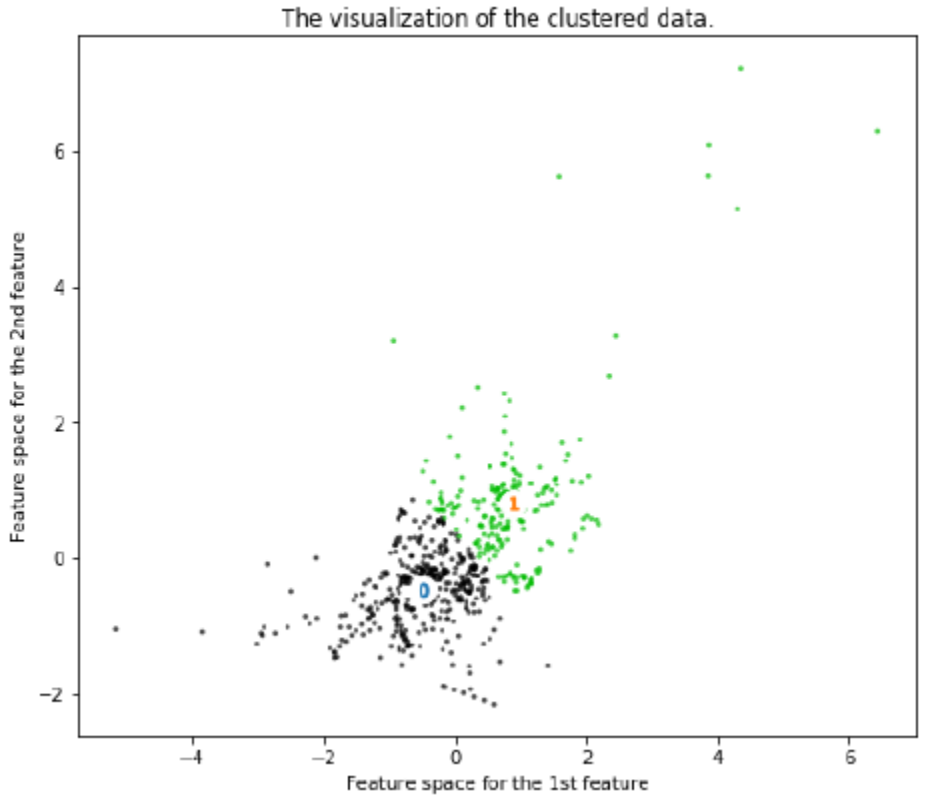




Clustering analysis on gaze points

Pilots from control group





Statistical analysis

- **Null hypothesis (H0): the mean of number of clusters of novice pilots does not differ from trained pilots or expert pilot**

- **Alternative Hypothesis (H1) : the mean of number of clusters of novice pilots does differ from trained pilots or expert pilot**

- **Two tailed T-test**
- **Confidence Level = 95%**

Obtained P-value: 0.097

Result: Reject H0

Discussion

- **Clustering analysis could be used to distinguish very bad pilots from good pilots**

- **Sample size should be increased to draw solid conclusion**
- **The finding could be used to establish a threshold for in flight visual entropy.**

- **Pilots should apply active scanning pattern in order to avoid:**
  - **Divided attention**
  - **Tunnel visioning**

Challenges

- **More than 10G data needed to be analyzed.**
- **Data wrangling**
  - **Eye tracking data has more than 100 columns**
  - **Flight data has more than 10 columns data**