Visual search using VR environment and Mathematical analysis of eye-gaze tracking data

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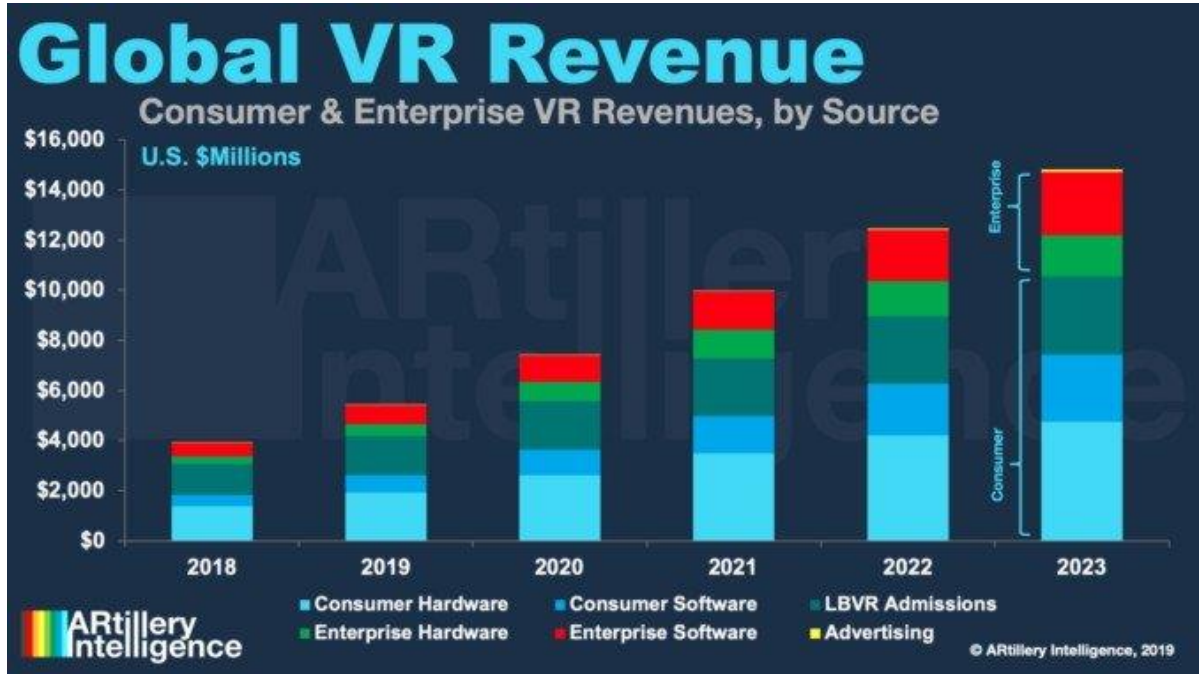
Introduction (1)

Background



Issues

What's the relationship between eye-gaze moving and perception ?

What's the mechanism of VR sickness ?

The VR market is expected to grow significantly in the future

Introduction (2)

Motivation

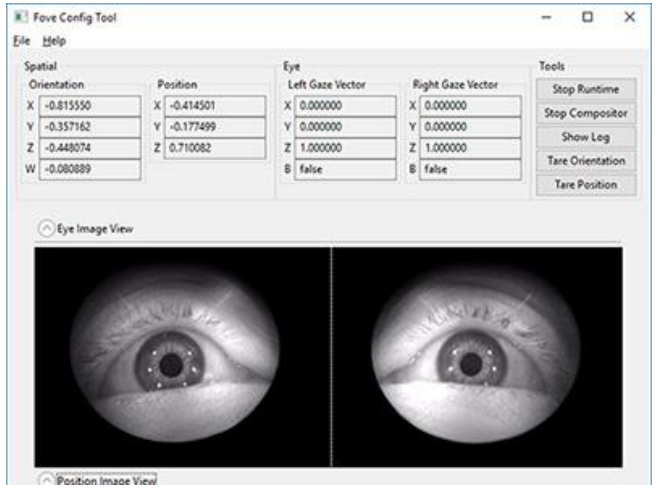
- Analyze map of eye-gaze moving and obtain key parameters to characterize human visual search
- Propose our original mathematical analysis methodologies

FOVE 0 VR

Methodology

- Obtain and analysis eye-gaze tracking data on FOVE 0 VR system using original software
- Clustered by K-Means method and Elbow method
- Classify search or stare using Gaze Density and Reaction time

Eye-gaze tracking system



Experiment and Results (1)

Experiment to search target on test pattern

Target

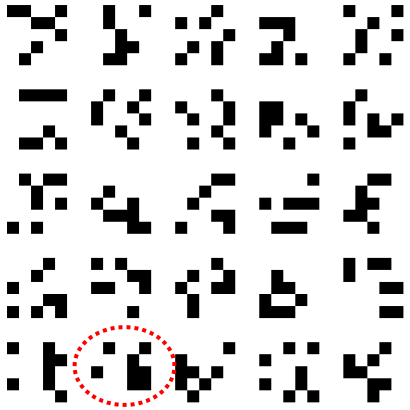
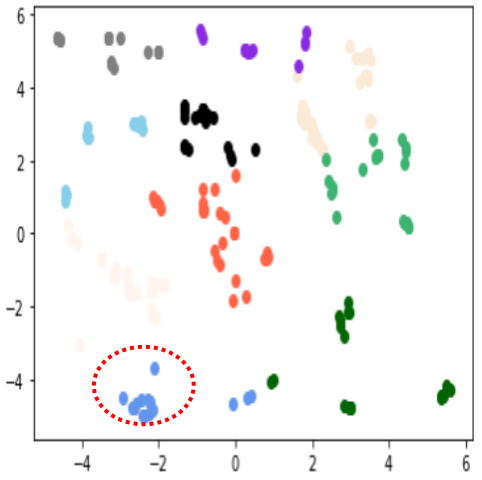


Fig. 1. Test pattern

Eye-gaze tracking data



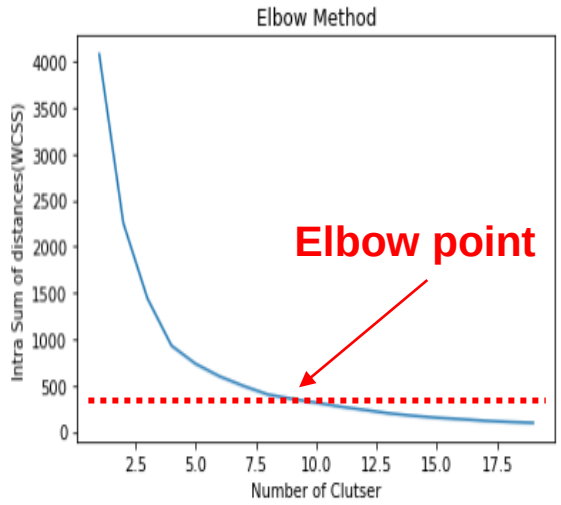


Fig.2. Clustered by K-Means and Elbow method

Clustering

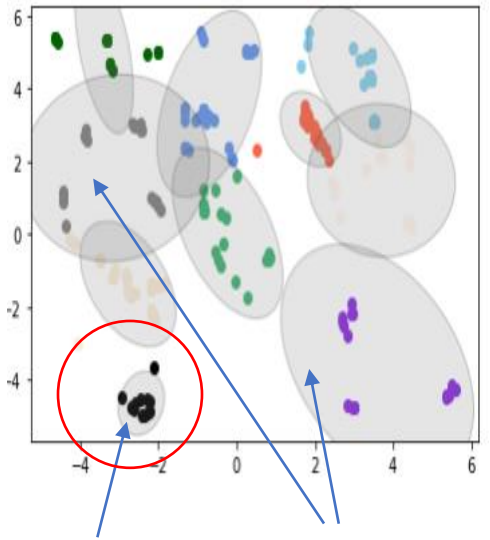


Fig.3. Clustered result

Experiment and Results (2)

K-Means method

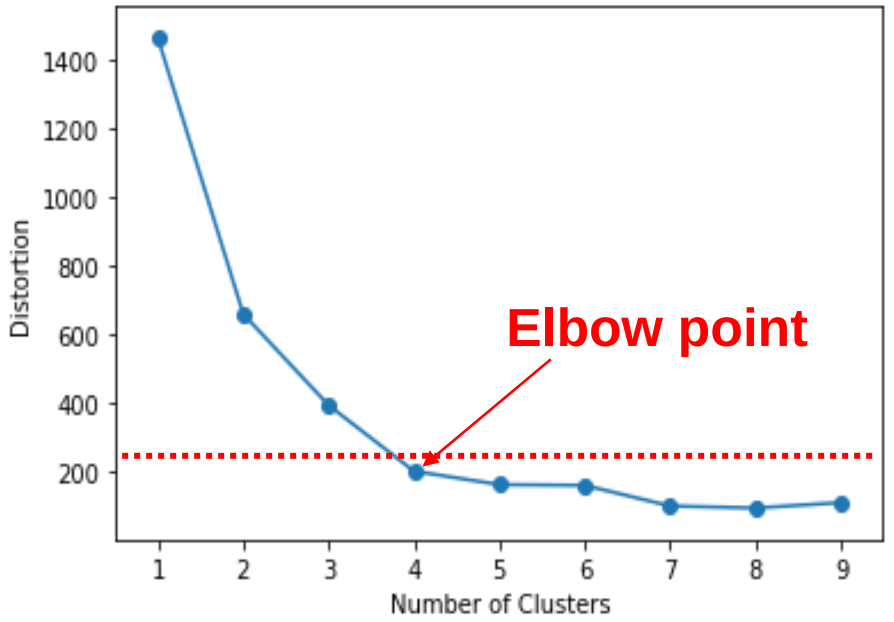
Clustered data using given number of clusters

The objective function

$$\sum_{i=1}^{K} \sum_{x \in X_i} \left\| x - \mu_i \right\|^2$$

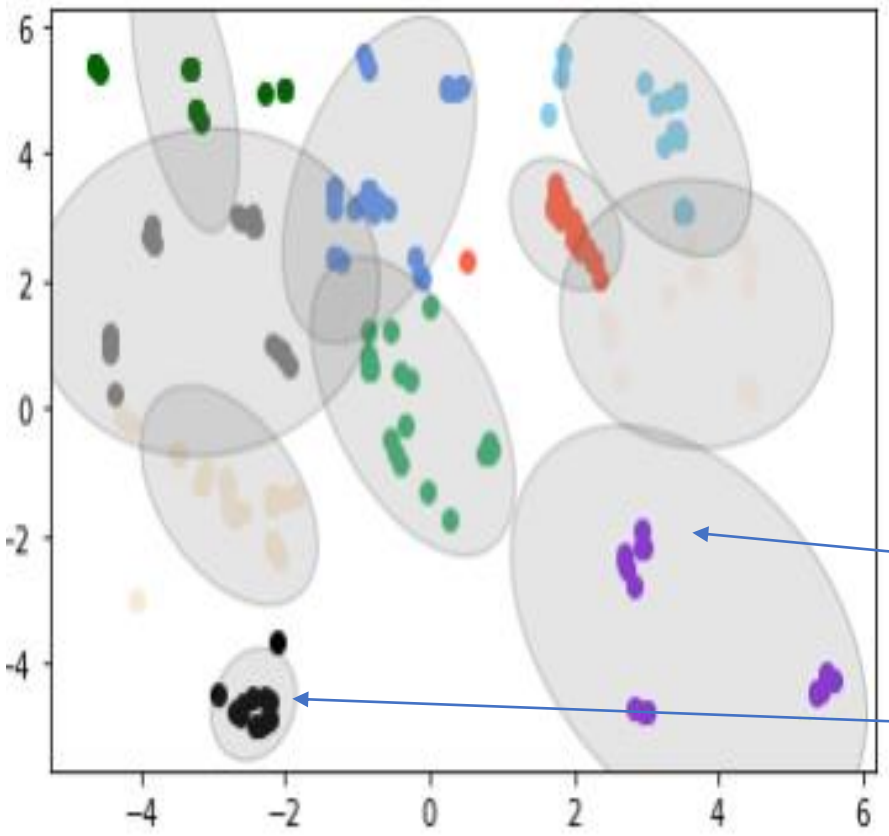
Elbow method

Optimization of number of clusters using calculation of distortion

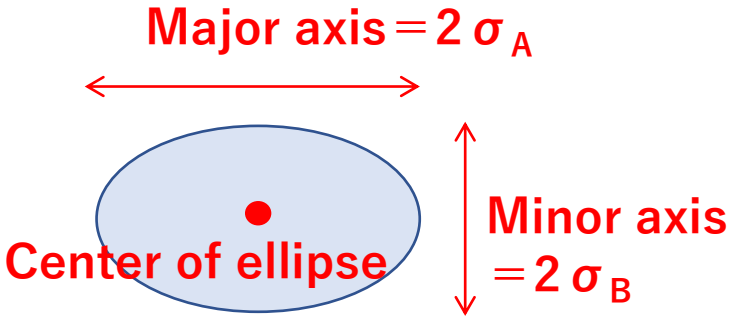


Experiment and Results (3)

Clarify parameters on “Probability Ellipse” to characterize clusters



Reaction time to find the target τ_R= 16.1 sec.



	中心座標	2 σ A	2 σ B
Searching	(3.59, -3.56)	7.01	4.26
Stare	(-2.43, -4.65)	1.78	1.15

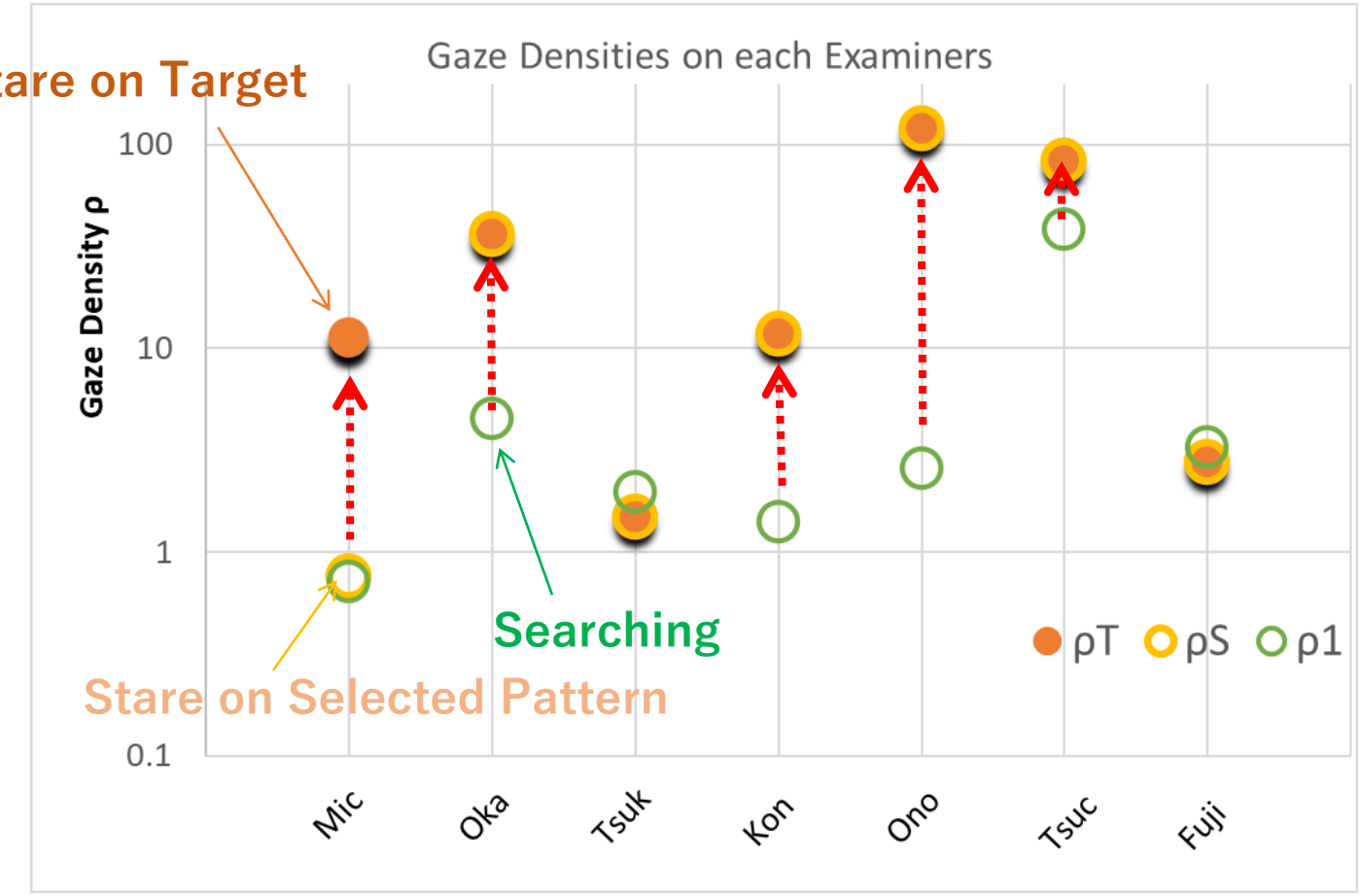
Experiment and Results (4)

Characterization of Gaze-search

Characterization of “Stare” and “Search” by key-parameter ρ.

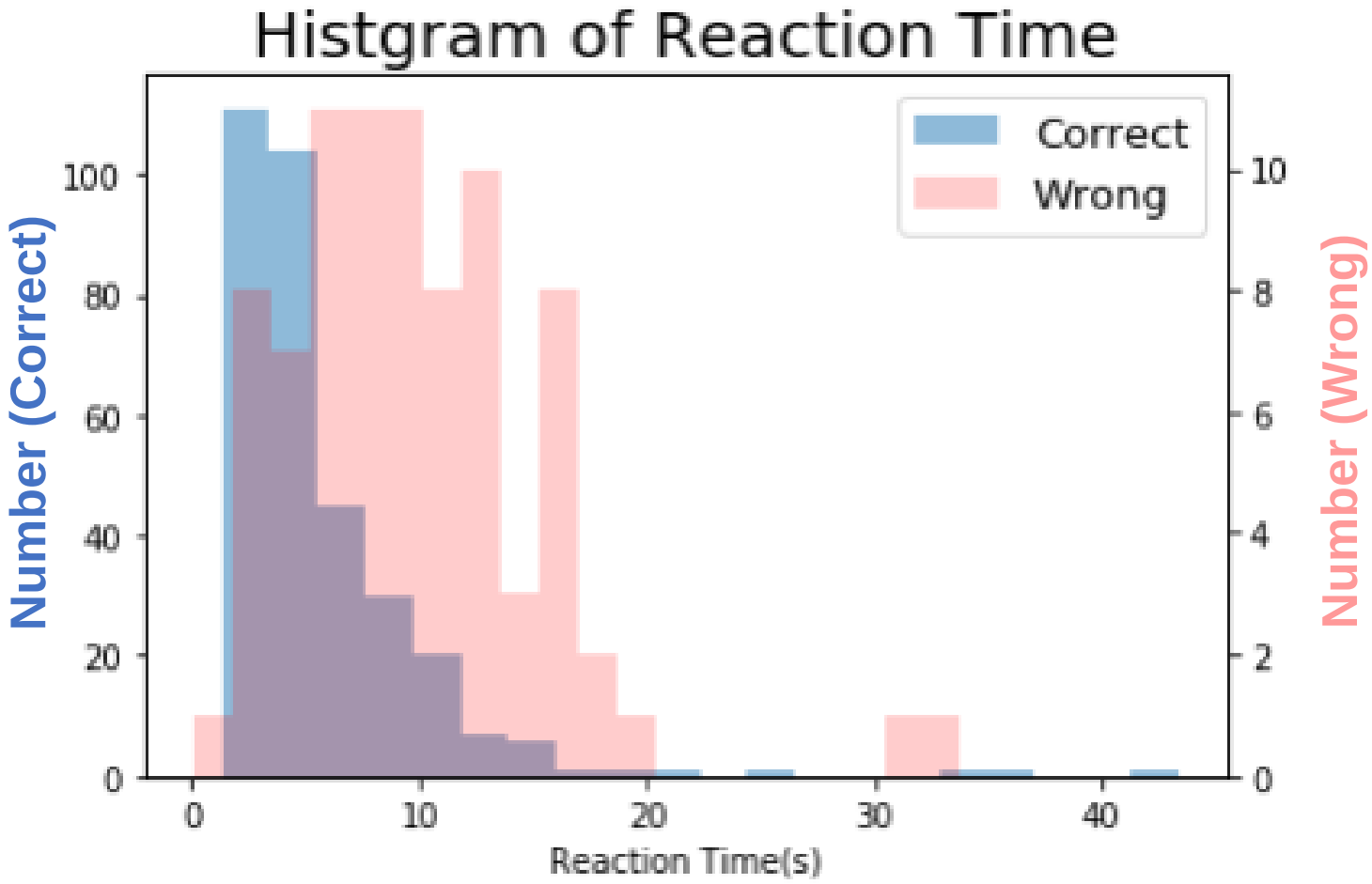
Gaze Density

$$\rho = \frac{\text{Gaze Points}}{\pi \, \sigma_A \sigma_B}$$

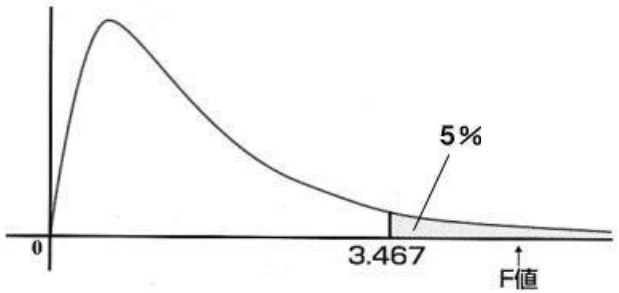


Experiment and Results (5)

Relationship between Searching and Reaction Time



F distribution

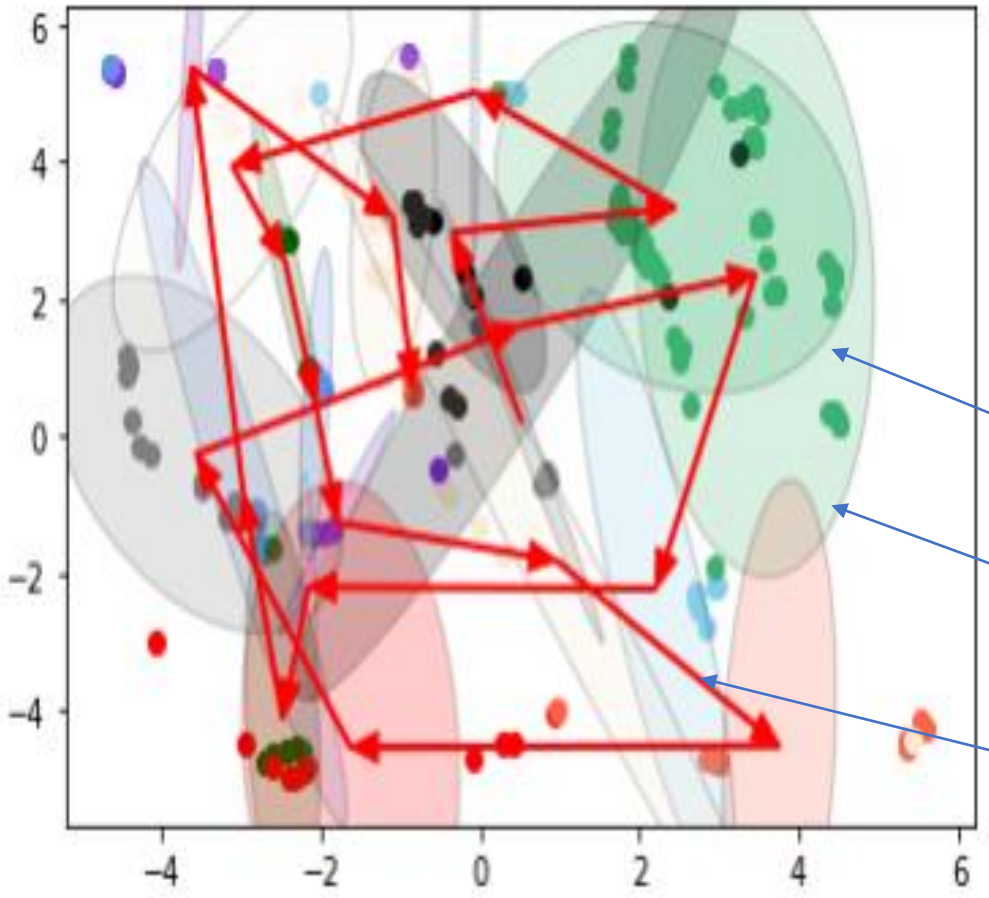


F test : P value

0.0235 < 0.05

Experiment and Results (6)

Auto transient analysis by original program




```
#ミケレット先生の２問目の目線データを使う
file_name = "実験その1/ミケレット先生３/xy0.text"
file_name2 = "実験その1/ミケレット先生３/xy.text"
men_list = ["ミケレット先生３", "岡島さん", "月田さん","今野さん", "小野さん", "土屋さん", "藤井君１

print("kmeansclusteringテスト")
file = open(file_name)
lines = file.readlines()
file.close()
first_line = lines[0].split()
l1 = first_line[0].split(':')
first_time = int(l1[0])*3600 + int(l1[1]) * 60 + float(l1[2])

def setData(file_name):
    pdata = pd.read_table(file_name, header=None)
    data = pdata.values

pdata = pd.read_table(file_name2,header=None)
data2 = pdata.values
pdata = pd.read_table(file_name, header=None)
data = pdata.values
```

Auto clustering

Generation of Probability ellipse

Generation of Gaze-trajectory between clusters

Future Works

Considering to decide time constant and frequency
as transient key parameters on eye-gaze tracking data

Experiments to obtain precursor of VR sickness as next step

Obtain precursors of VR sickness ?

Summary

- We obtained eye-gaze vector and coordinates data on FOVE 0 gaze-tracking platform
- We characterized behavior of the eye-gaze vector and obtained characteristic movements of “Stare” and “Search”
- We proposed key-parameters to characterize gaze-moving
- We also proposed our original mathematic analysis methodologies