Development of real time supervisor emotional state tracking system

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Supervisory control systems

- Quality of decision making in SCS depends on professional and psychological factors like:
  - Competence
  - Speed of thought
  - Memory
  - Involvement
  - Stress
  - …

Problem

- The impact of the psycho-emotional state in the decision making process is poorly understood
- Psychological factors are not well described in any SCS standard

Goal

- Development of real time supervisor emotion state tracking system

Objectives

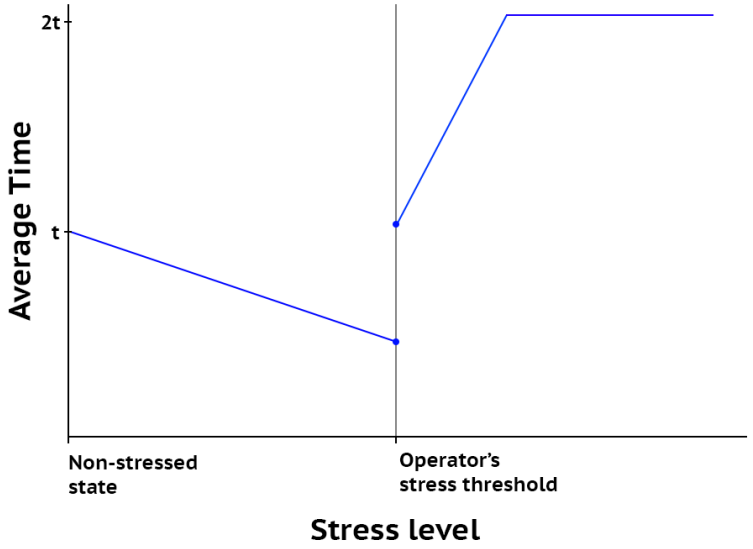
Man-machine model
A. Siegel and J. Wolf

Stress level factors:

- Individual operator reaction – stress level increase as result of time lag during tasks execution
- Failure to successfully complete all elements of the job on the first try
- The need to wait for a response from machine

Model features

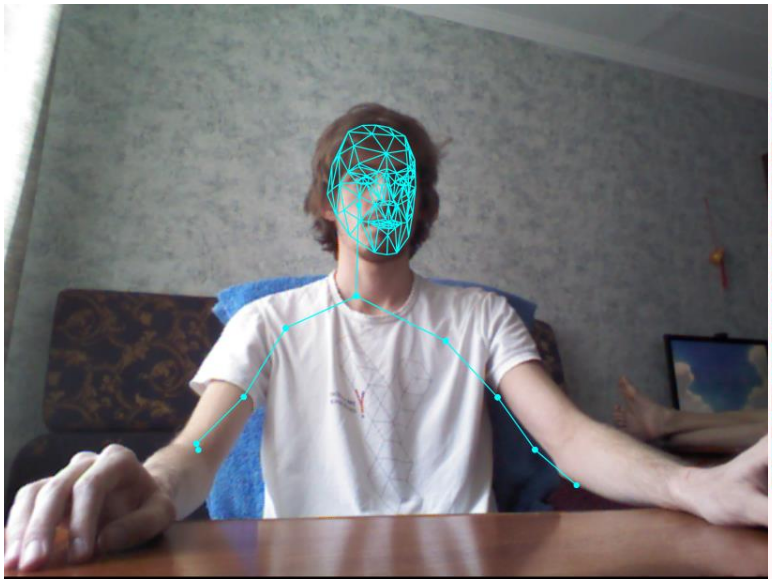
- Sub-task time dependent on the stress level
- Success or failure dependent on the stress level

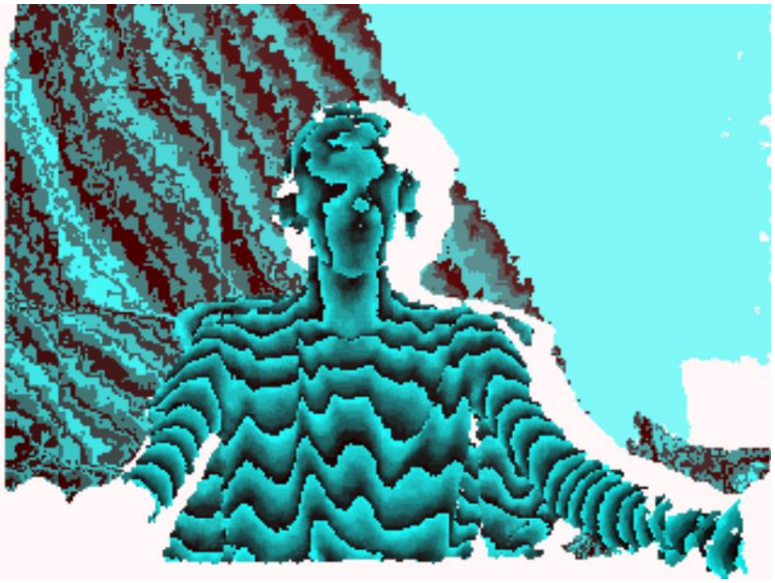


Platform: Microsoft **Kinect**

Kinect output

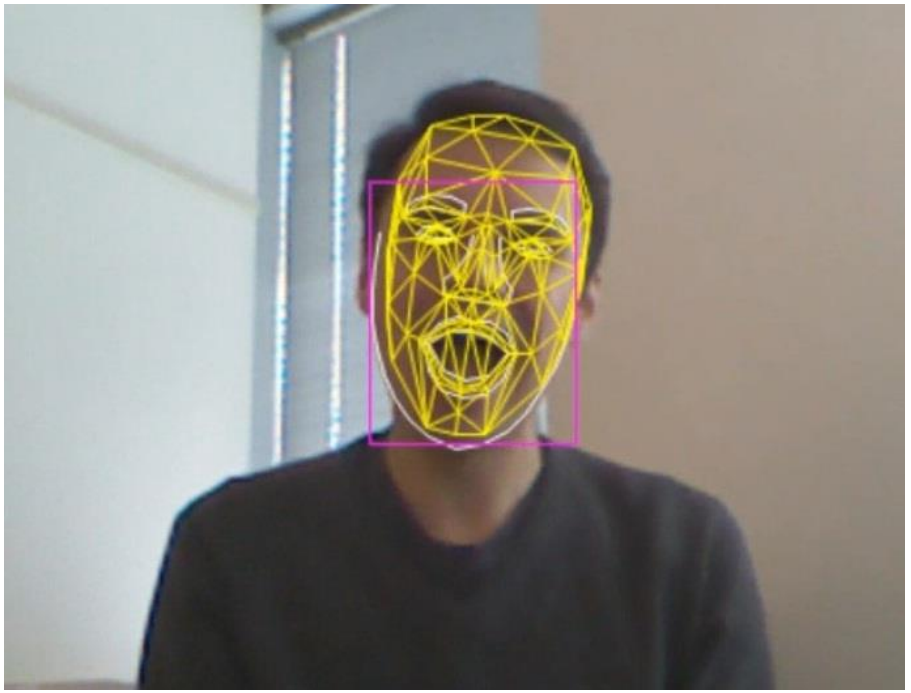
Color stream	Depth stream	Tracked skeletons	Positioned audio





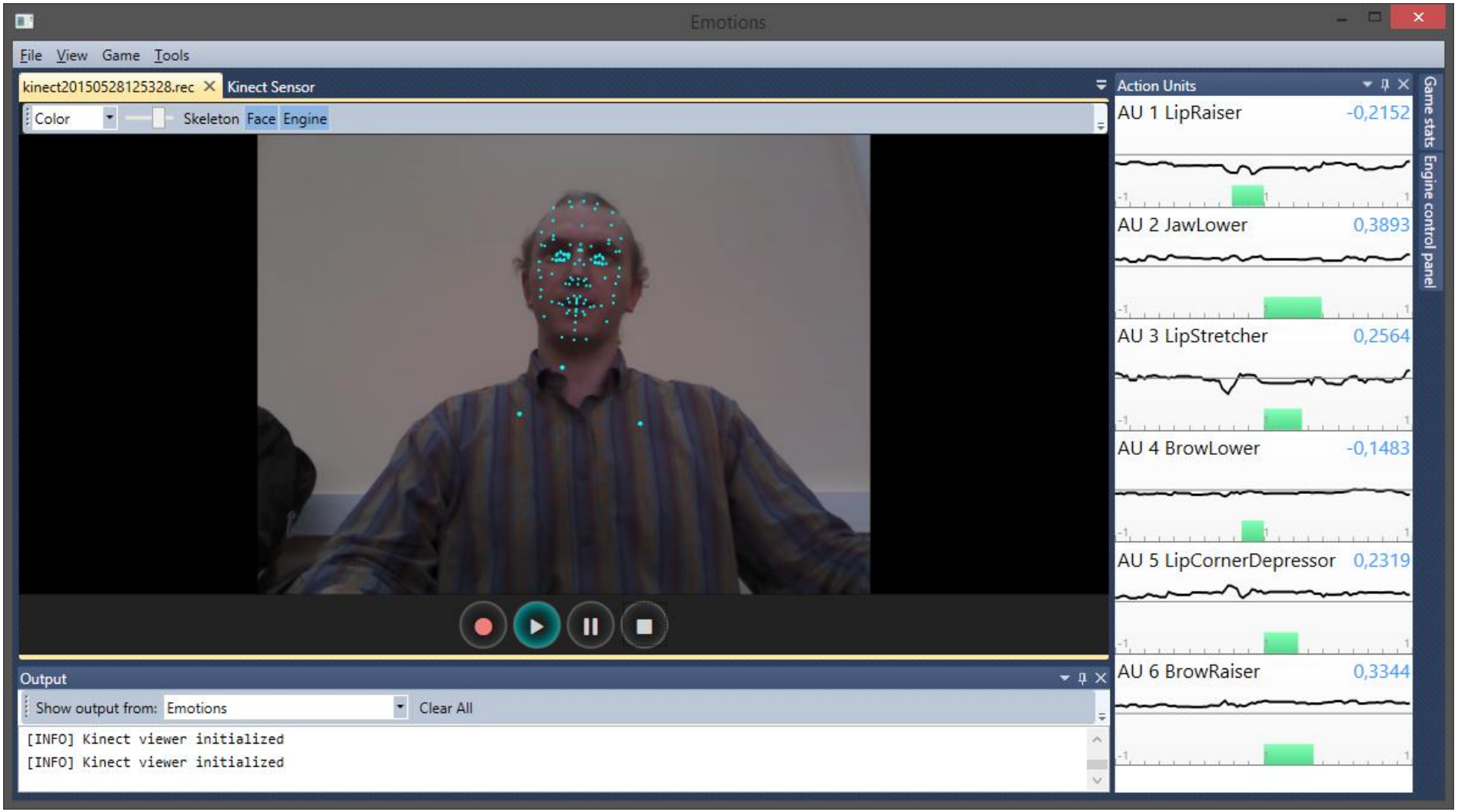
Kinect face tracking Toolkit

- CANDIDE-3 Face Model
- 87 Feature Points
- 6 Action Units:
  - Lip Raiser
  - Jaw Lowerer
  - Lip Stretcher
  - Brow Lowerer
  - Lip Corner Depressor
  - Brow Raiser



Development of the tracking tool

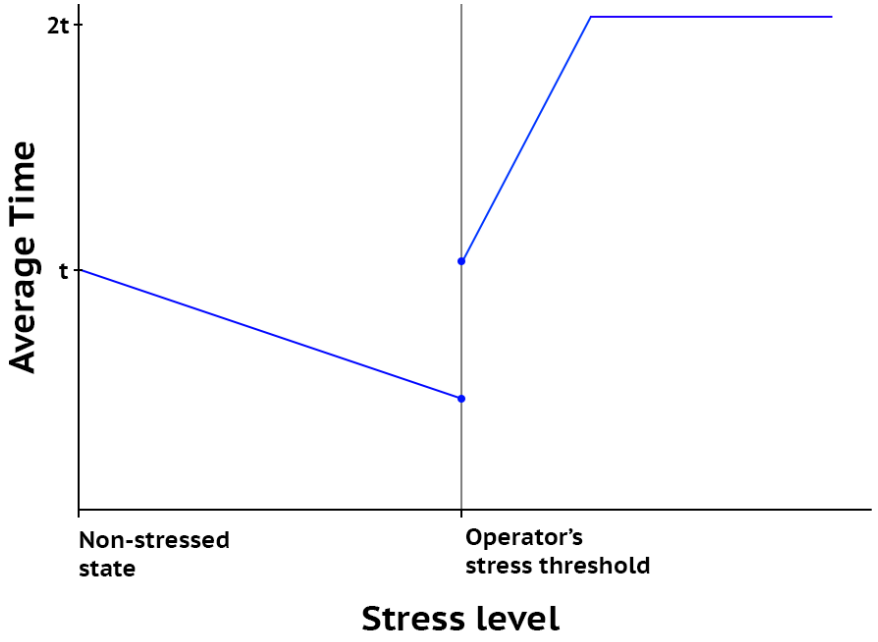
- Uses Microsoft Kinect for capturing color and depth stream, skeleton joint position, face position and face parameters
- Recording and playback capability
- Stress emulation game
- Data analysis, preview and export
- Real time stress state identification
- Notifications



The source code available at
https://github.com/bshishov/Emotions

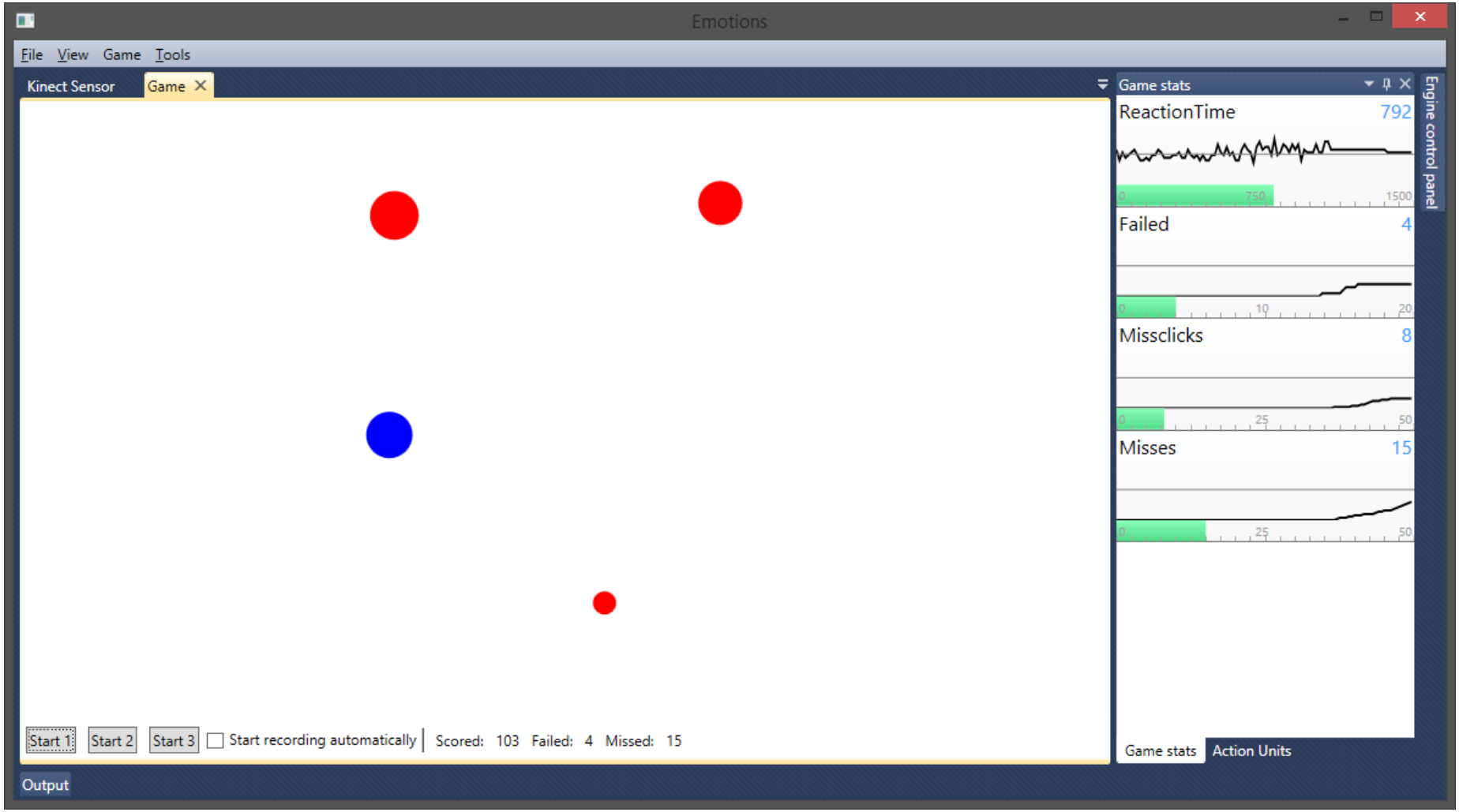
Experiment development

- Sub-tasks
- Succeeds and failures
- Linearly increasing stress level



Stress emulator development

- Task: Click on the objects of one specific type
- Fixed experiment time (3 minutes)
- Tasks appear faster over time
  - Easy mode. Operator performs 100% of tasks.
  - Concentrated mode. Operator can make mistakes but he increases his concentration on performing tasks.
  - Hard mode. Operator can’t perform tasks before new tasks appears which causes increase of a stress level.
- Same experiment conditions for all
- Extract 2 points from result:
  - Transition between relaxed (normal) state to concentrated state
  - Transition between concentrated state to stressed state

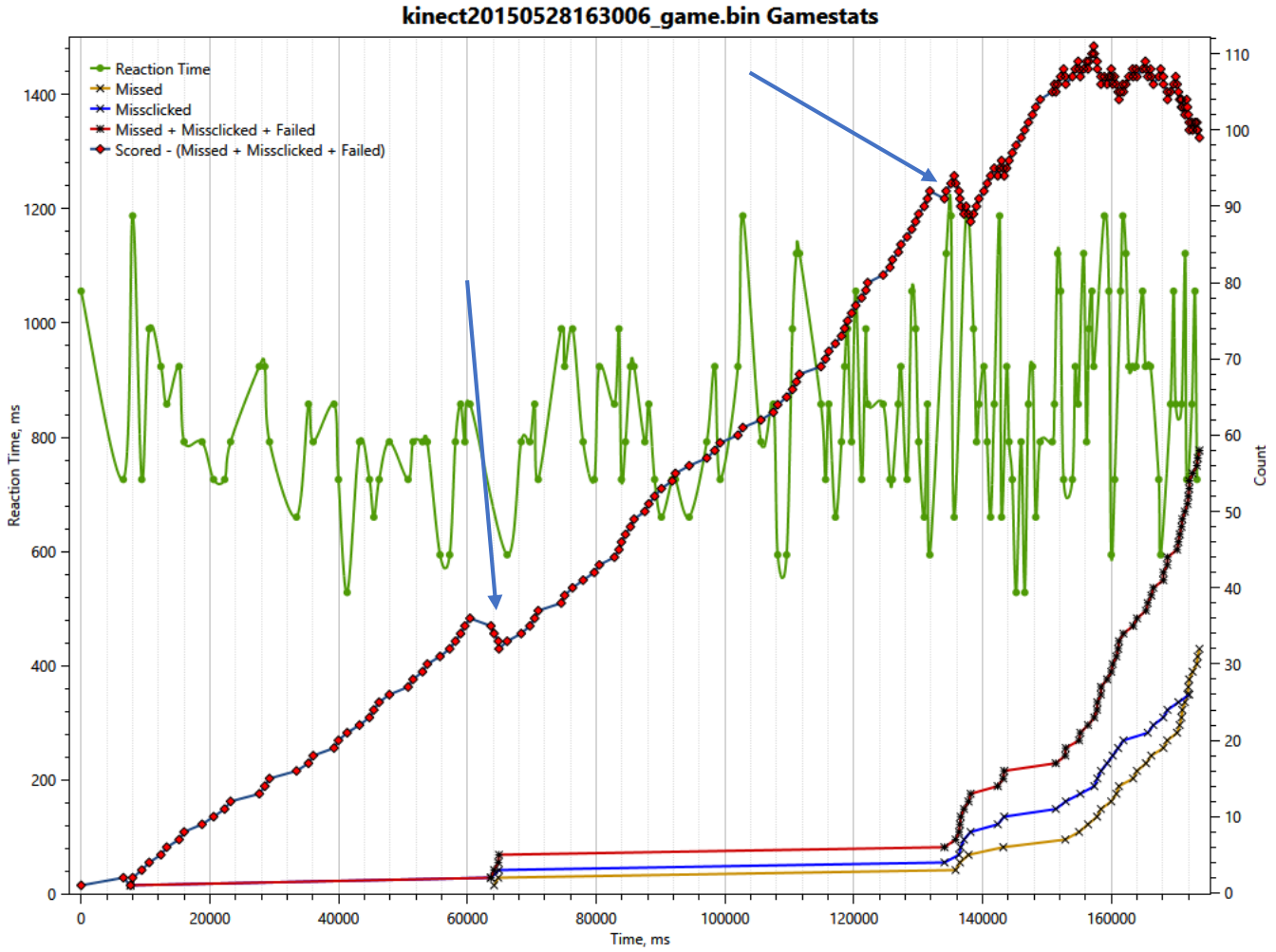

Emotions
File View Game Tools
Kinect Sensor
Game
Game stats
ReactionTime 792
0 750 1500
Failed 4
0 10 20
Missclicks 8
0 25 50
Misses 15
0 25 50
Engine control panel
Start 1
Start 2
Start 3
Start recording automatically
Scored: 103 Failed: 4 Missed: 15
Game stats
Action Units
Output

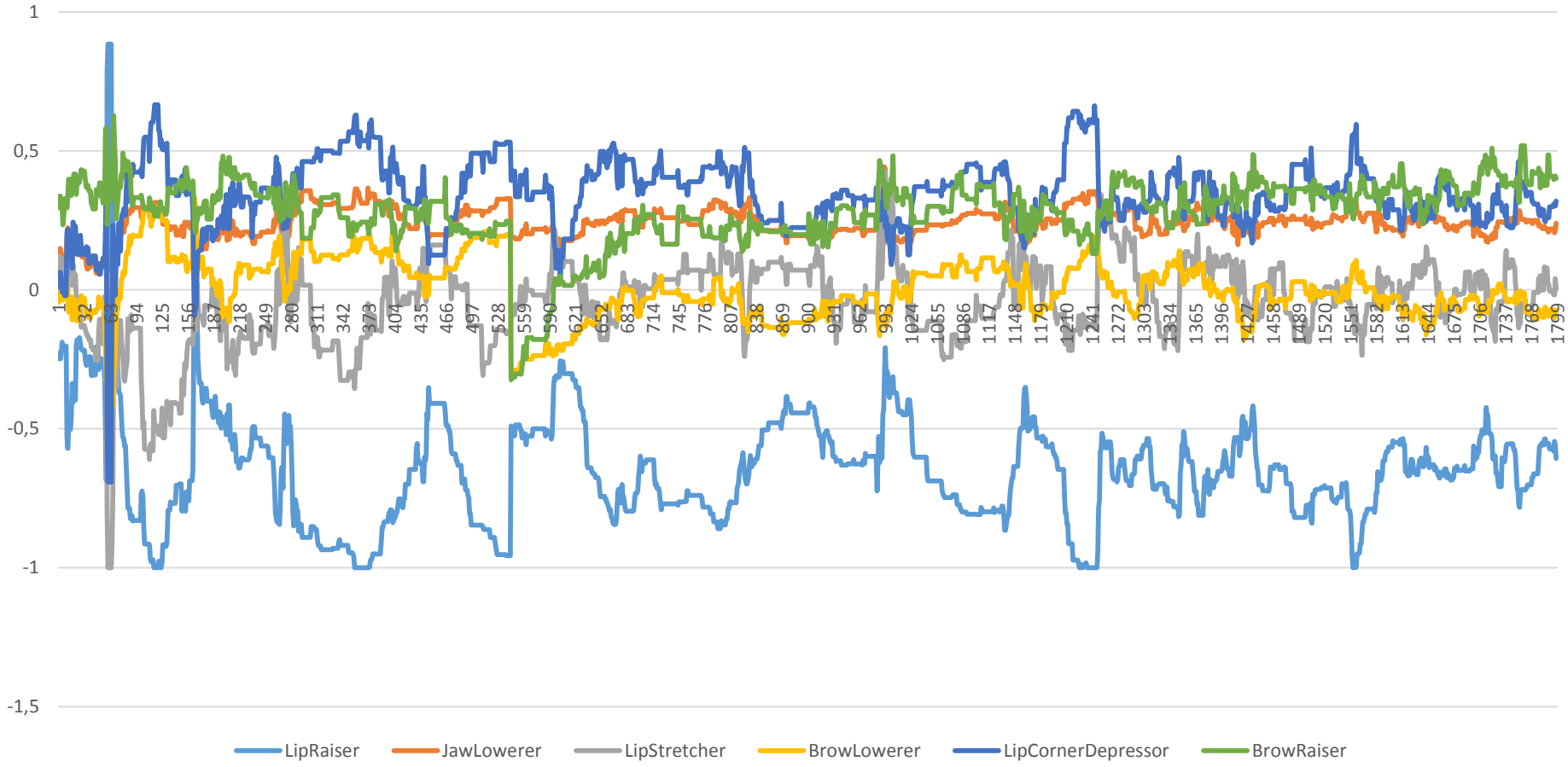
Stress emulator

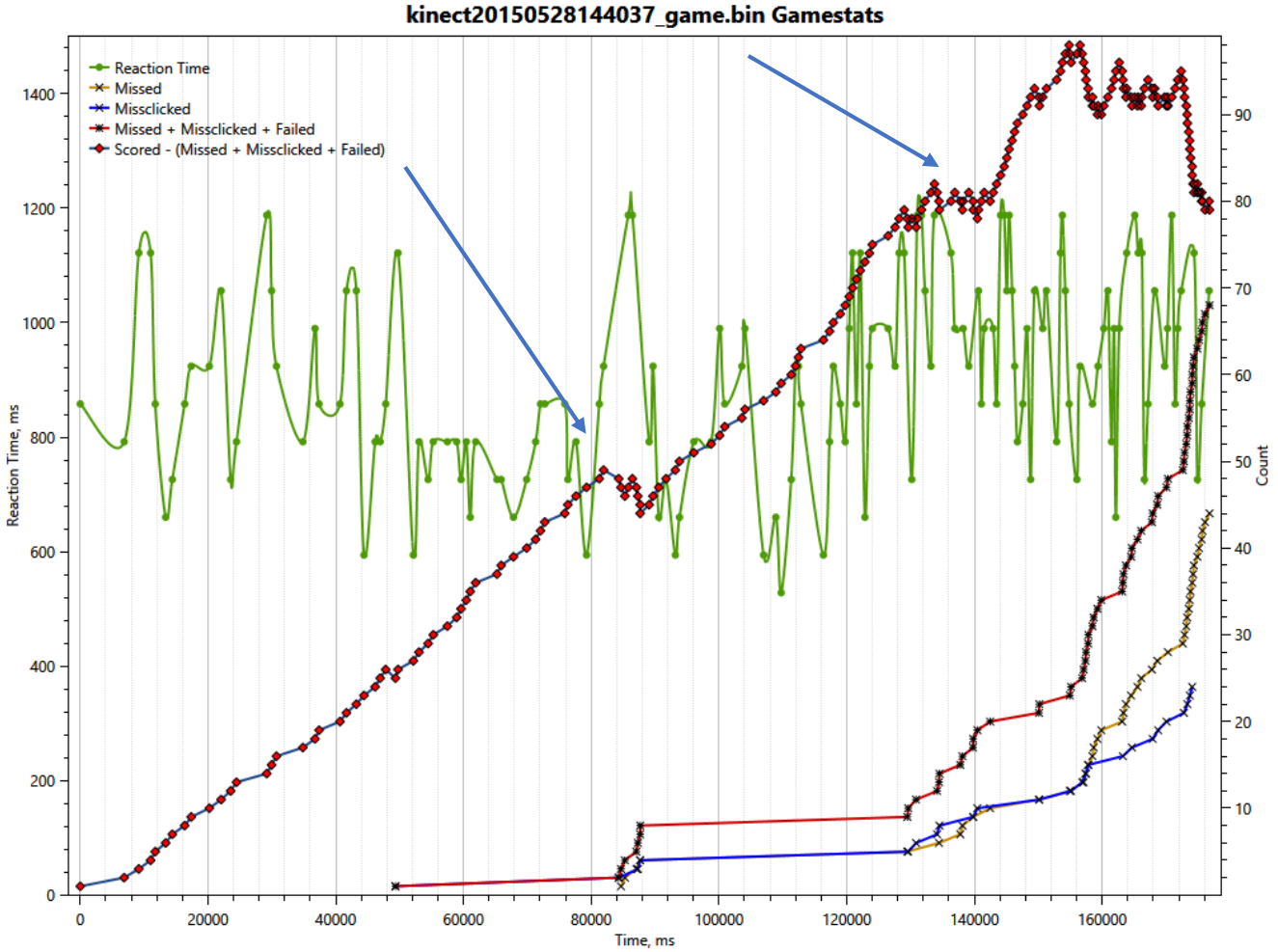
- Reaction time – time between a circle created and being clicked
- Succeeds – clicks on blue circles
- Fails
  - Misclicks
  - Clicks on red
  - Missed
- Video (color stream) and depth stream
- Skeleton joint positions
- Face position
- 6 face AU parameters

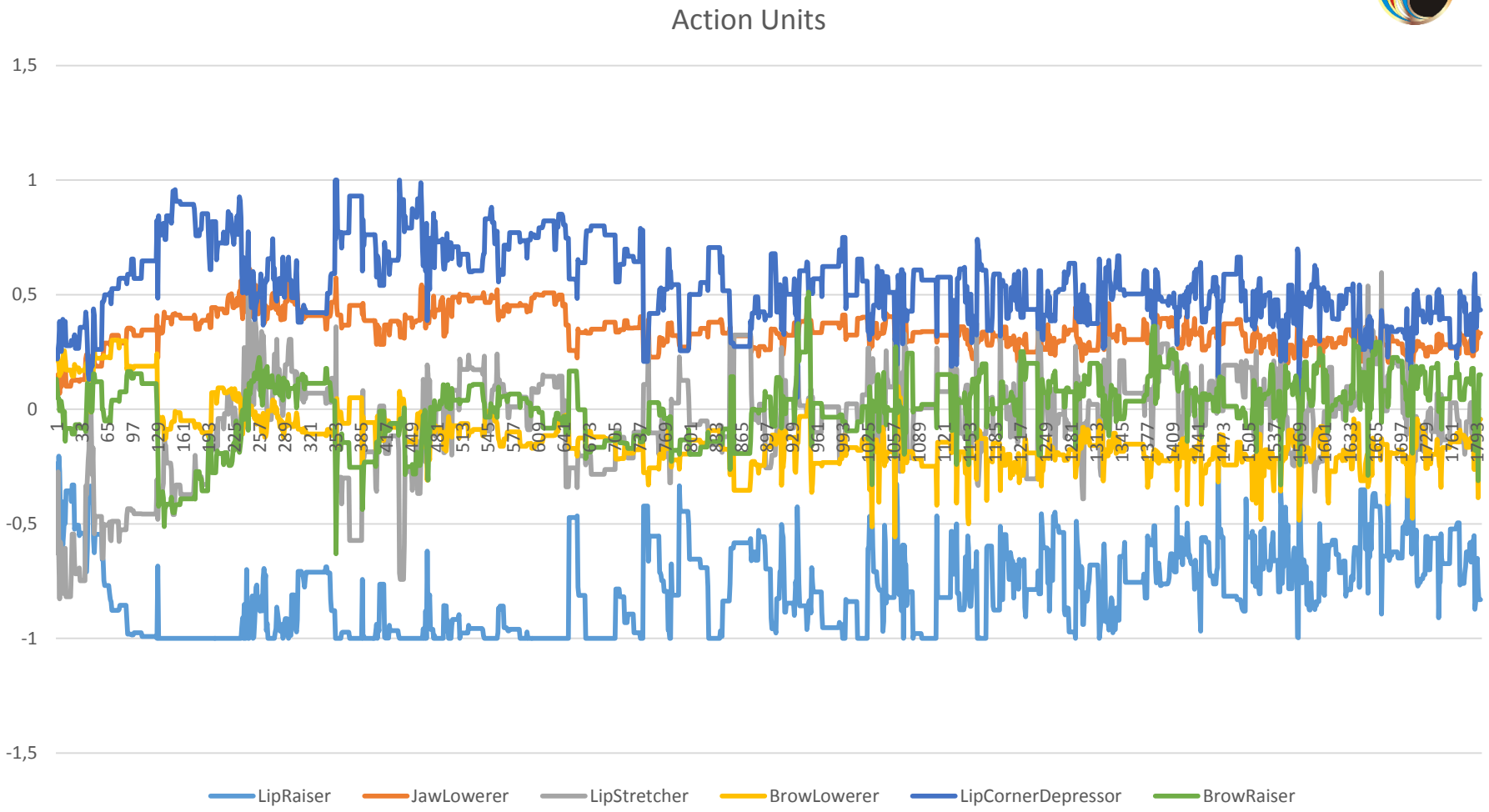
Experiment results

- 21 people recorded
- Some people in the course of the experiment showed a clear change of the emotional state


kinect20150528163006_game.bin Gamestats
Reaction Time
Missed
Missclicked
Missed + Missclicked + Failed
Scored - (Missed + Missclicked + Failed)
Reaction Time, ms
Count
Time, ms
0
200
400
600
800
1000
1200
1400
0
10
20
30
40
50
60
70
80
90
100
110
0
20000
40000
60000
80000
100000
120000
140000
160000

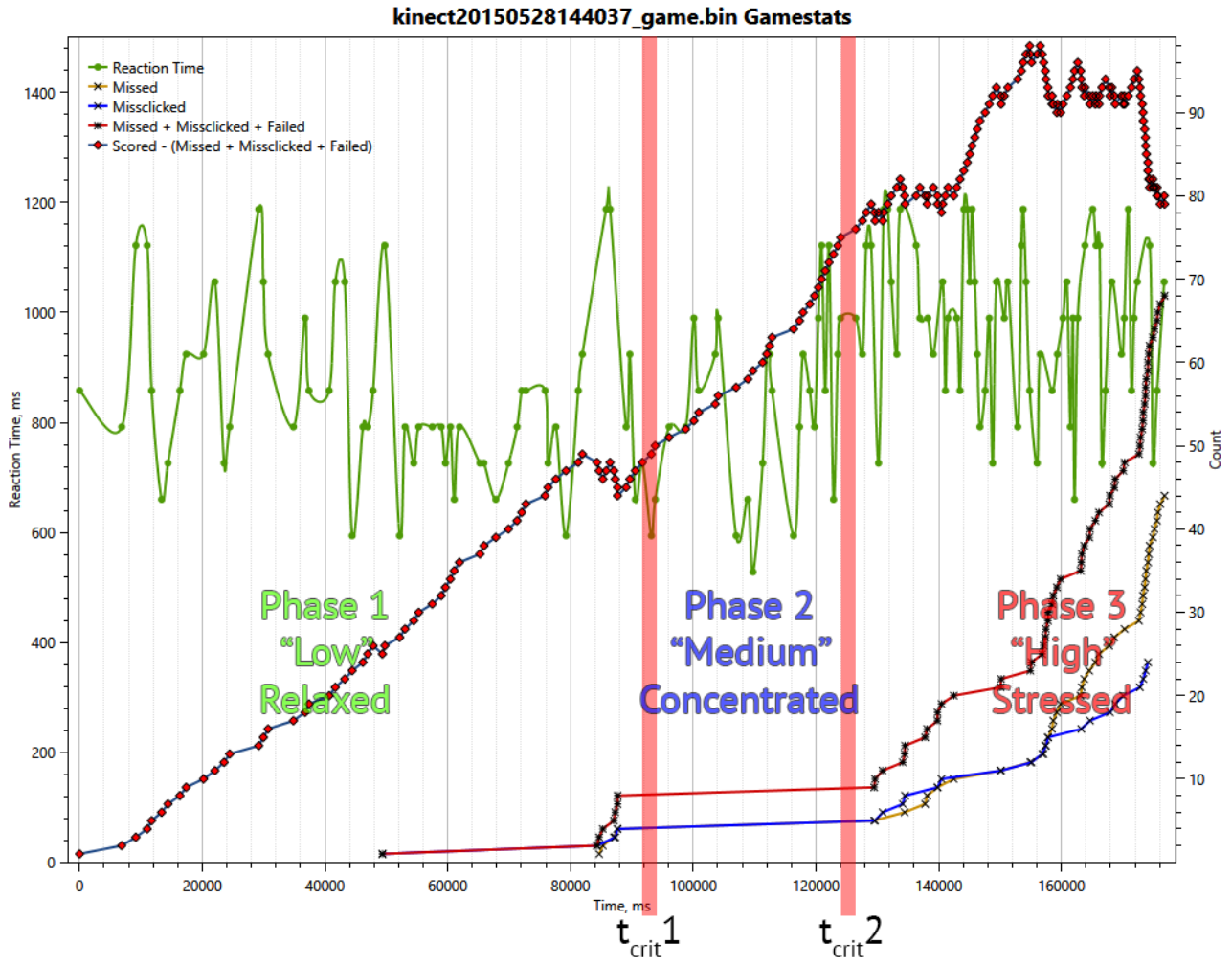

Action Units
1
0,5
0
-0,5
-1
-1,5
LipRaiser
JawLowerer
LipStretcher
BrowLowerer
LipCornerDepressor
BrowRaiser


kinect20150528144037_game.bin Gamestats
Reaction Time
Missed
Missclicked
Missed + Missclicked + Failed
Scored - (Missed + Missclicked + Failed)
Reaction Time, ms
Count
Time, ms
0
200
400
600
800
1000
1200
1400
10
20
30
40
50
60
70
80
90
0
20000
40000
60000
80000
100000
120000
140000
160000


Action Units
1,5
1
0,5
0
-0,5
-1
-1,5
1
33
65
97
129
161
193
225
257
289
321
353
385
417
449
481
513
545
577
609
641
673
705
737
769
801
833
865
897
929
961
993
1025
1057
1089
1121
1153
1185
1217
1249
1281
1313
1345
1377
1409
1441
1473
1505
1537
1569
1601
1633
1665
1697
1729
1761
1793
LipRaiser
JawLowerer
LipStretcher
BrowLowerer
LipCornerDepressor
BrowRaiser

Data analysis

- Split each experiment data manually into 3 phases (Low, Medium and High) based on reaction time and failures series.
- Define parameters for each experiment
  - T_{cr1} – time when low phase ends and mid phase starts
  - T_{cr2} – time when mid phase ends and end phase starts
  - τ_1 – average reaction time in 1st phase
  - τ_2 – average reaction time in 2nd phase
  - τ_3 – average reaction time in 3rd phase
  - F_1 – average failures in 1st phase
  - F_2 – average failures in 2nd phase
  - F_3 – average failures in 3rd phase


kinect20150528144037_game.bin Gamestats
Reaction Time
Missed
Missclicked
Missed + Missclicked + Failed
Scored - (Missed + Missclicked + Failed)
Reaction Time, ms
Count
Time, ms
Phase 1
"Low"
Relaxed
Phase 2
"Medium"
Concentrated
Phase 3
"High"
Stressed
t crit 1
t crit 2

Experiments parameters

#	tcrit1	tcrit2	Tau1	Tau2	Tau3	F1	F2	F3
1	87000	120000	934,07	897,11	998,65	1,15	2,00	46,53
2	90000	120000	932,11	929,28	984,00	0,11	6,28	33,83
3	60000	140000	1012,50	994,21	1039,32	4,00	27,60	77,18
4	60000	110000	1024,94	994,50	1038,46	11,29	24,73	83,84
5	85000	115000	772,10	752,89	877,80	3,10	7,04	24,19
6	95000	117000	869,31	849,20	957,22	4,36	16,13	50,99
7	80000	115000	969,69	964,45	1026,61	3,52	15,06	68,79
8	92000	110000	904,84	888,46	987,15	1,19	3,85	35,93
9	90000	120000	879,32	865,92	948,44	1,83	8,92	40,41
10	96000	120000	897,81	882,32	966,17	3,67	8,68	47,49
11	90000	110000	957,97	831,60	1064,35	7,47	17,80	73,95
12	90000	125000	877,16	821,59	990,00	1,35	8,00	32,94
13	70000	110000	913,22	958,94	944,09	4,45	13,91	49,49
14	90000	110000	955,48	907,50	956,37	7,43	16,88	62,94
15	90000	136000	907,08	898,50	986,59	13,59	26,80	67,92
16	66000	120000	815,69	787,29	941,34	0,00	0,50	28,07
17	60000	118000	924,00	854,26	1028,43	8,88	19,57	80,27
18	90000	130000	862,00	852,65	862,79	5,92	11,22	43,32
19	90000	110000	813,29	781,85	854,23	2,42	5,00	23,84
20	94000	138000	706,52	706,20	958,08	0,82	1,00	27,97
21	96000	120000	882,75	826,94	1031,56	1,89	2,00	31,27
	83857,14	**119714,3**	**895,8026**	**868,8407**	**973,4116**	**4,211494**	**11,56918**	**49,10262**

- $\tau_1 > \tau_2$ – higher stress level provides better reaction
- $\tau_3 > \tau_2$ – stress raised up higher than the operators stress threshold which provides bad reaction time
- $F_3 > F_2 > F_1$ – higher stress level affects failures count

Parameters analysis

- Correlation matrix (highly correlated parameters are highlighted)

	tcrit1	tcrit2	Tau1	Tau2	Tau3	F1	F2	F3
tcrit1	1	0,014935	-0,41319	-0,43323	-0,28848	-0,28562	-0,46783	-0,52776
tcrit2	0,014935	1	-0,21124	-0,11515	0,031264	-0,00432	0,126288	-0,01402
Tau1	-0,41319	-0,21124	1	0,903666	0,665289	0,448887	0,661632	0,791381
Tau2	-0,43323	-0,11515	0,903666	1	0,471502	0,35814	0,616088	0,666953
Tau3	-0,28848	0,031264	0,665289	0,471502	1	0,248801	0,401751	0,644767
F1	-0,28562	-0,00432	0,448887	0,35814	0,248801	1	0,831869	0,767033
F2	-0,46783	0,126288	0,661632	0,616088	0,401751	0,831869	1	0,885304
F3	-0,52776	-0,01402	0,791381	0,666953	0,644767	0,767033	0,885304	1

- τ_1 is the most significant parameter

Parameters classification *using k-means*

#	tcrit1	tcrit2	Tau1	Tau2	Tau3	F1	F2	F3
1	87000	120000	934,07	897,11	998,65	1,15	2,00	46,53
2	90000	120000	932,11	929,28	984,00	0,11	6,28	33,83
3	60000	140000	1012,50	994,21	1039,32	4,00	27,60	77,18
4	60000	110000	1024,94	994,50	1038,46	11,29	24,73	83,84
5	85000	115000	772,10	752,89	877,80	3,10	7,04	24,19
6	95000	117000	869,31	849,20	957,22	4,36	16,13	50,99
7	80000	115000	969,69	964,45	1026,61	3,52	15,06	68,79
8	92000	110000	904,84	888,46	987,15	1,19	3,85	35,93
9	90000	120000	879,32	865,92	948,44	1,83	8,92	40,41
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16	66000	120000	815,69	787,29	941,34	0,00	0,50	28,07
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18	90000	130000	862,00	852,65	862,79	5,92	11,22	43,32
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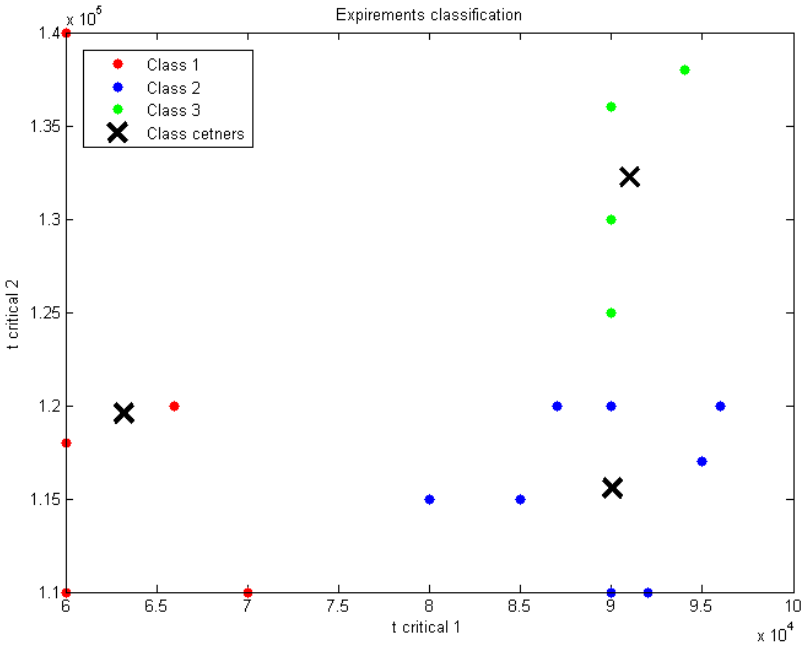
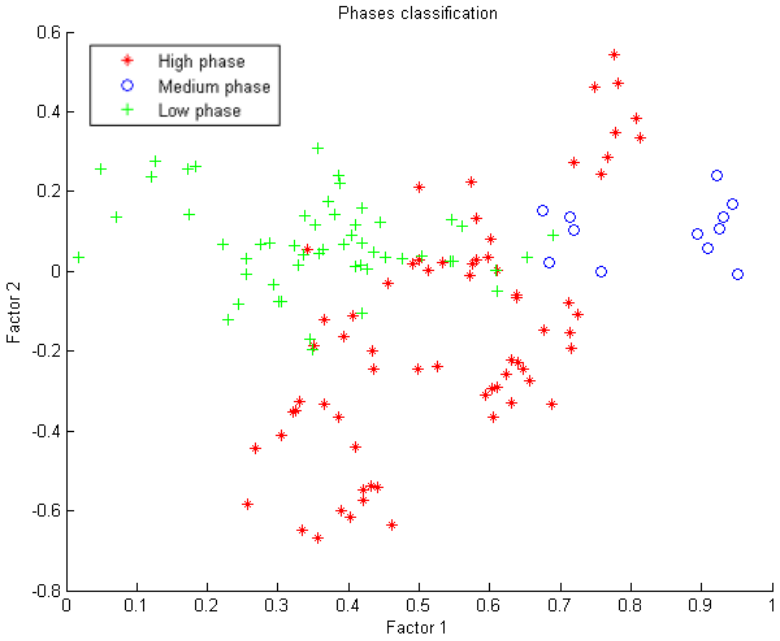
21	96000	120000	882,75	826,94	1031,56	1,89	2,00	31,27
	83857,14	119714,3	895,8026	868,8407	973,4116	4,211494	11,56918	49,10262

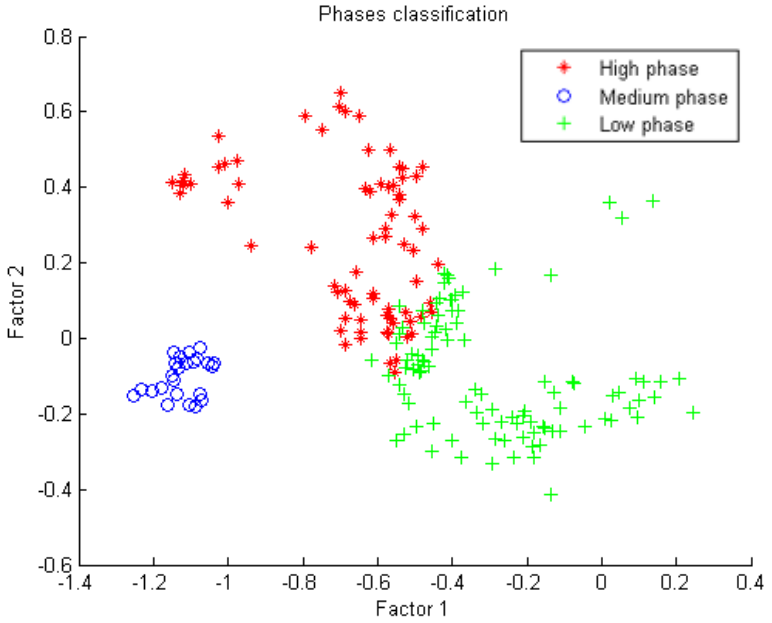


Factor analysis using PCA

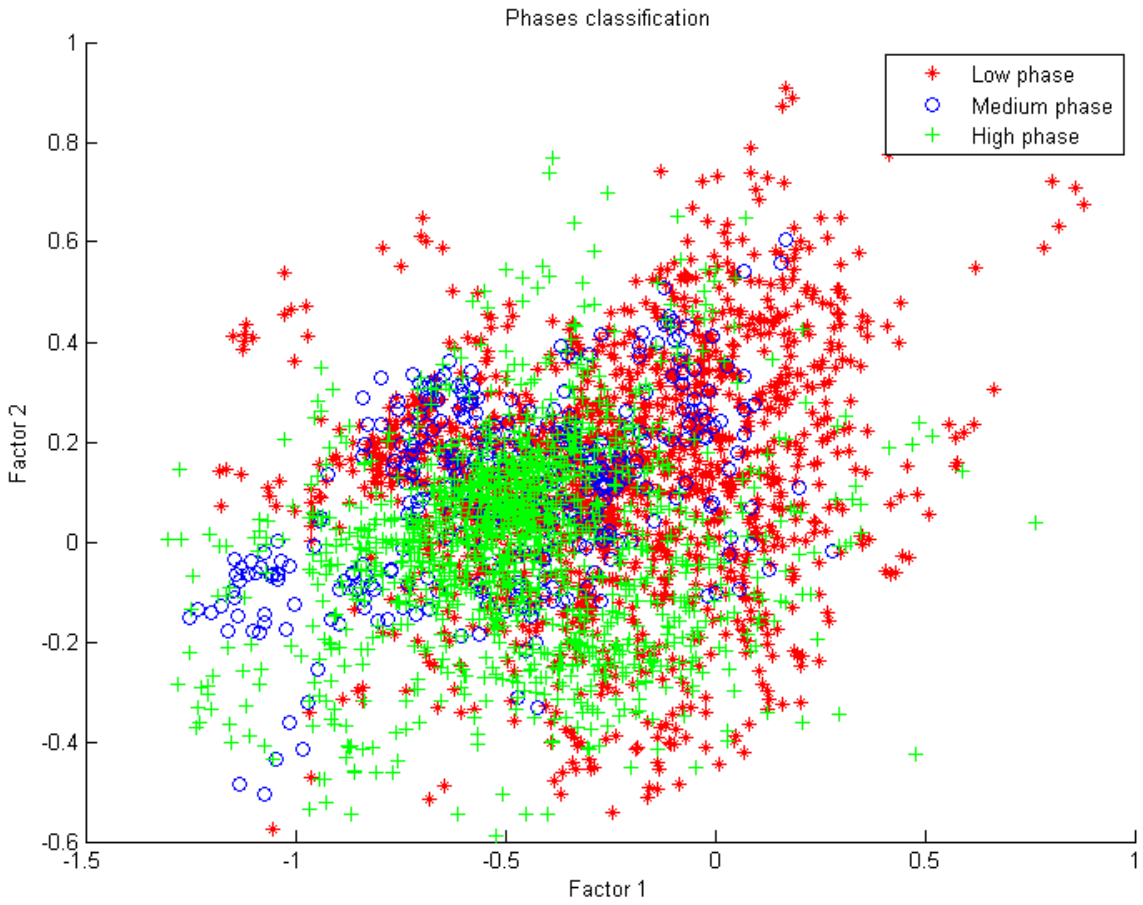
- For better classification we need to decrease the number of variables
- Our variables:
  - 6 face AU (Brow lowerer, lip stretcher…)
  - Head position
  - Shoulders position
  - Face position
  - Face rotation
- Using PCA we obtain 2 main factors that covers 60% variance of our variables.

Individual differences





Classification problem



Summary and main conclusions

- Run about 20 experiments to measure different stress levels of different individuals
- Developed a tool to capture and record emotional state based on A. Siegel and J. Wolf model
- Multiple steps were taken to “cleanse” the data
  - Analyzed correlation between key parameters
  - Extracted the core class of average-grade players
- Analyzed emotional state changes during experiment
  - Unable to establish universal correlation under assumptions
  - However, individual emotional traits can be clearly seen

Thank you for attention