Machine Learning for Pattern Recognition in EEG signals

Intelligent Tutoring Systems

Answer prediction

Language Proficiency

Security
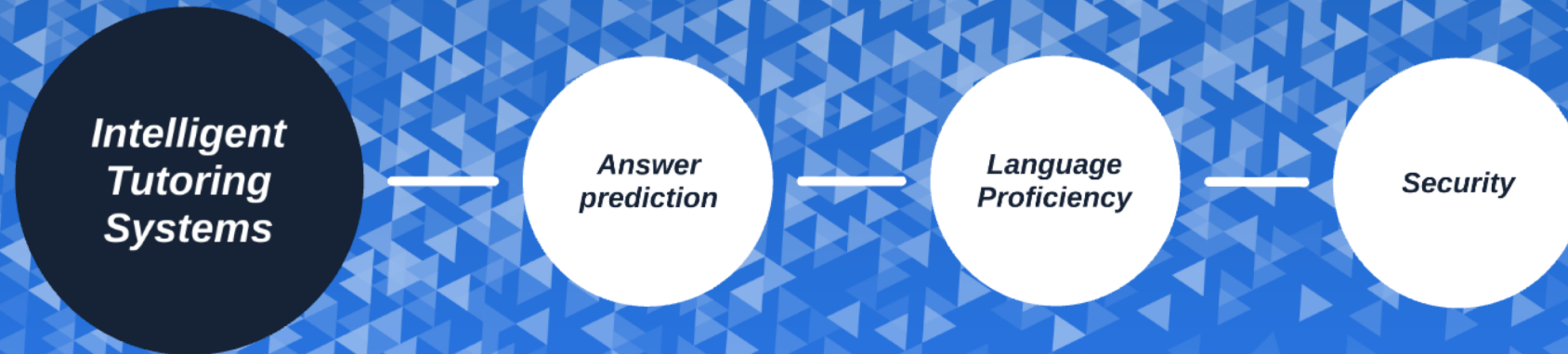
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August 2018
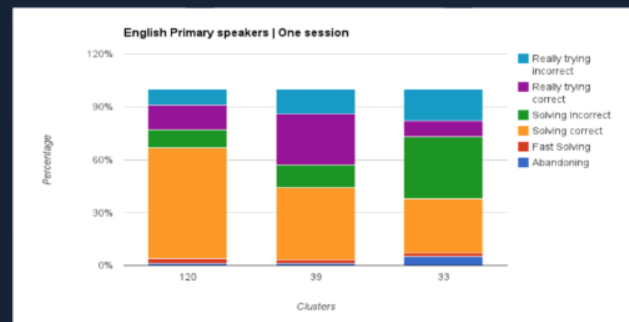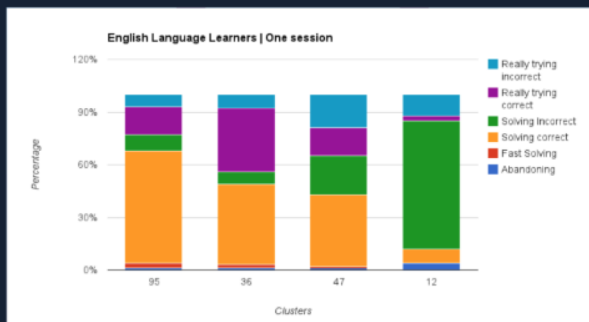
Electroencephalogram (EEG)

9 sensors
37 channels (3 to 40 Hz)
256 records per second
30 minutes average
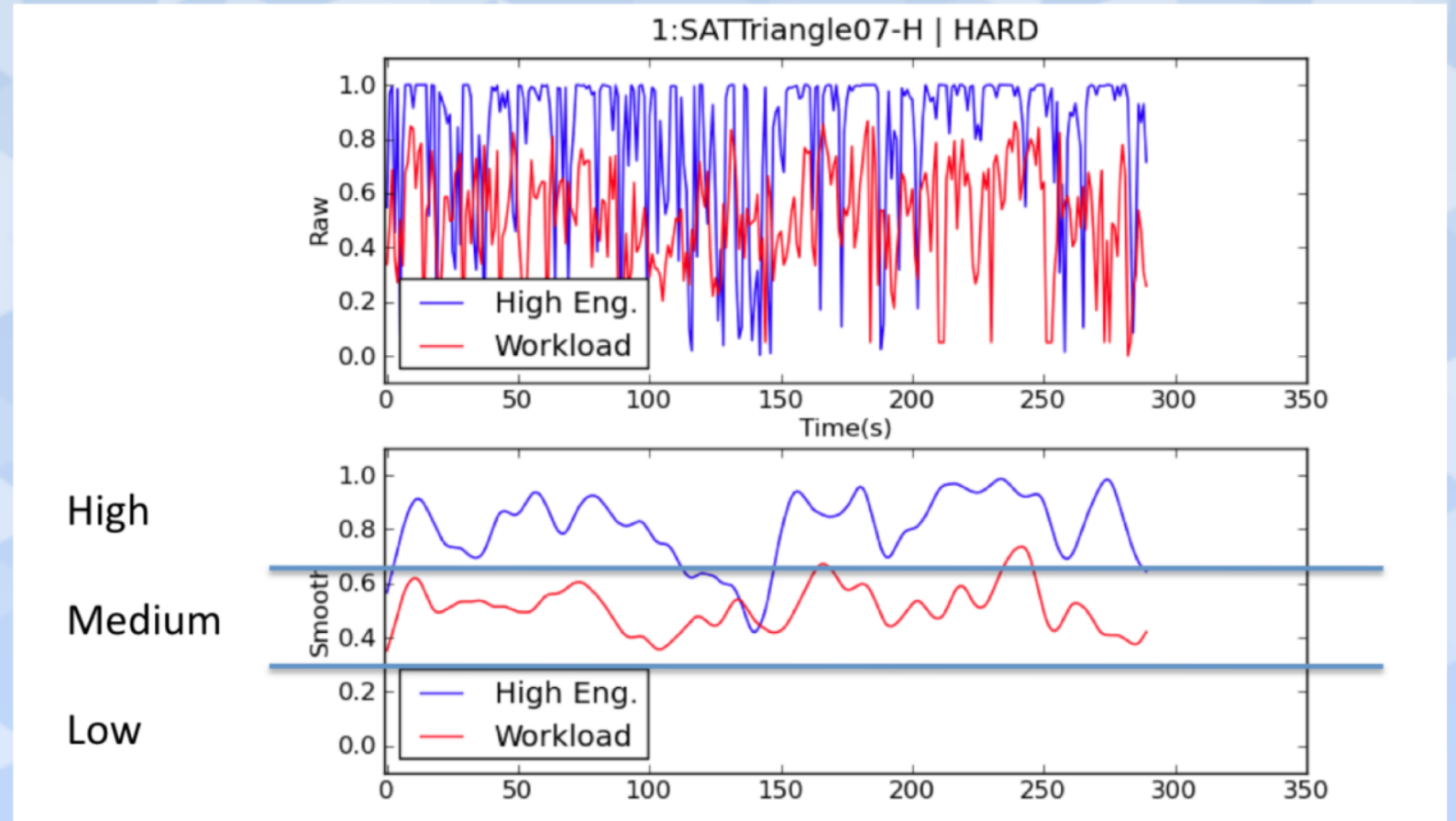
States

States

Low Engagement
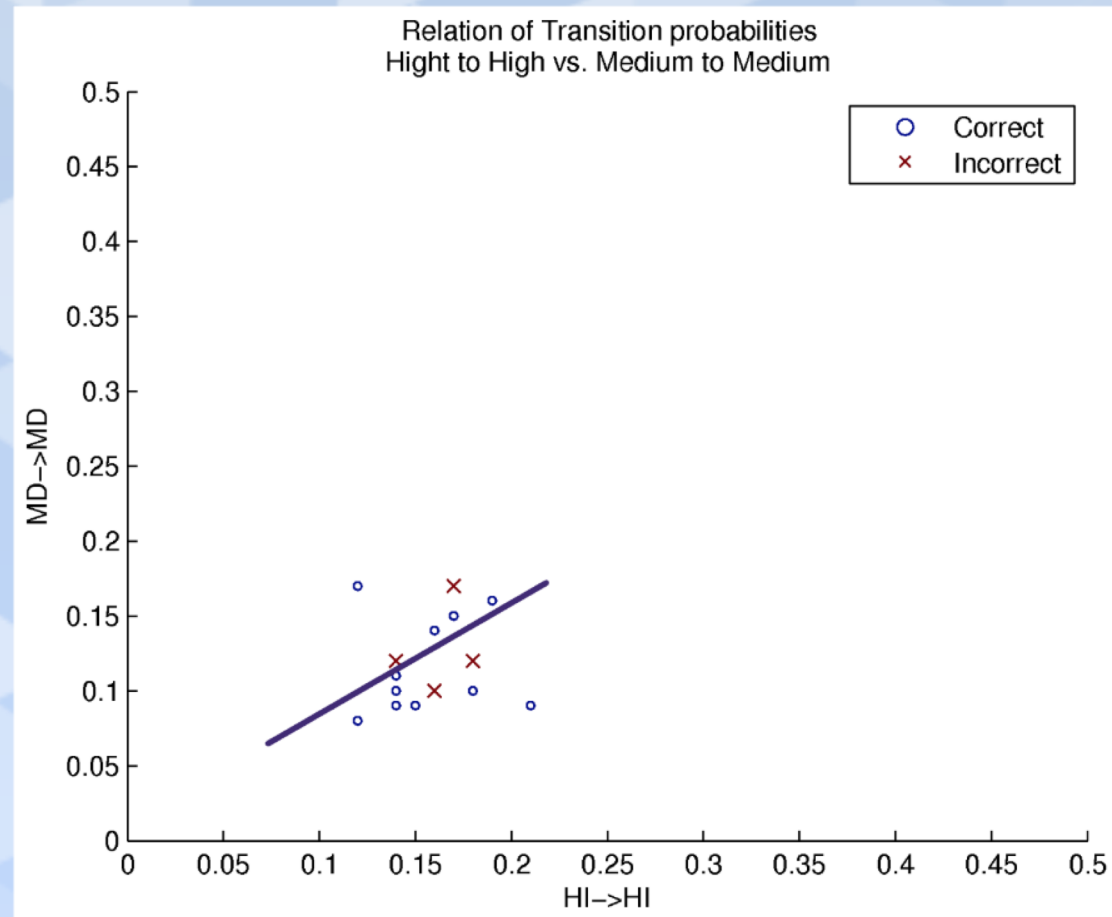High Engagement
Drowsy
Distraction
Workload

State transition

HI-HI	HI-MD	HI-LO	MD-MD	MD-HI	MD-LO	LO-LO	LO-HI	LO-MD	class
0.2	0.09	0.05	0.1	0.1	0.13	0.15	0.05	0.14	+1
0.16	0.11	0.07	0.1	0.11	0.12	0.14	0.06	0.12	-1
0.14	0.12	0.08	0.11	0.11	0.11	0.14	0.09	0.1	-1
0.15	0.12	0.07	0.13	0.08	0.12	0.15	0.1	0.08	+1
0.16	0.09	0.08	0.12	0.11	0.11	0.15	0.08	0.11	-1
0.18	0.1	0.07	0.1	0.1	0.13	0.13	0.07	0.13	+1
0.18	0.1	0.06	0.14	0.08	0.11	0.15	0.08	0.1	+1
0.18	0.13	0.03	0.1	0.14	0.09	0.23	0	0.1	+1
0.17	0.1	0.06	0.1	0.1	0.13	0.14	0.07	0.12	+1
0.11	0.13	0.09	0.13	0.06	0.15	0.09	0.15	0.09	+1
0.15	0.11	0.09	0.09	0.09	0.15	0.09	0.09	0.15	+1
0.17	0.06	0.1	0.15	0.09	0.09	0.14	0.08	0.12	-1
0.18	0.08	0.08	0.15	0.11	0.08	0.17	0.05	0.11	+1
0.19	0.09	0.06	0.11	0.11	0.11	0.16	0.04	0.13	-1
0.16	0.12	0.06	0.13	0.12	0.09	0.19	0.06	0.08	-1
0.16	0.11	0.07	0.1	0.11	0.12	0.13	0.07	0.12	-1

Support Vector Machines

Relation of Transition probabilities
Hight to High vs. Medium to Medium

First 20 seconds

| Easy problems	Base rate Accuracy	Cross validation accuracy			
		Engagement	Workload	Eng. & Wkld	Max(Eng, Wkld)
Bows	75%	75%	88%	88%	88%
Class	50%	88%	69%	75%	88%
Summation	93%	93%	93%	93%	93%
Village	44%	75%	81%	63%	81%
Average	**65%**	**83%**	**83%**	**80%**	**87%**
Hard problems	Base rate Accuracy	Engagement	Workload	Eng. & Wkld	Max(Eng, Wkld)
Bus	62%	75%	75%	69%	75%
Fence	62%	81%	69%	63%	81%
Towns	56%	81%	63%	69%	81%
Triangle	50%	75%	63%	63%	75%
Average	**57%**	**78%**	**67%**	**66%**	**78%**
Both	**62%**	**80%**	**75%**	**73%**	**83%**

Language Proficiency Estimation

WORKLOAD SMOOTH Detrended | 5:SATBus11-H
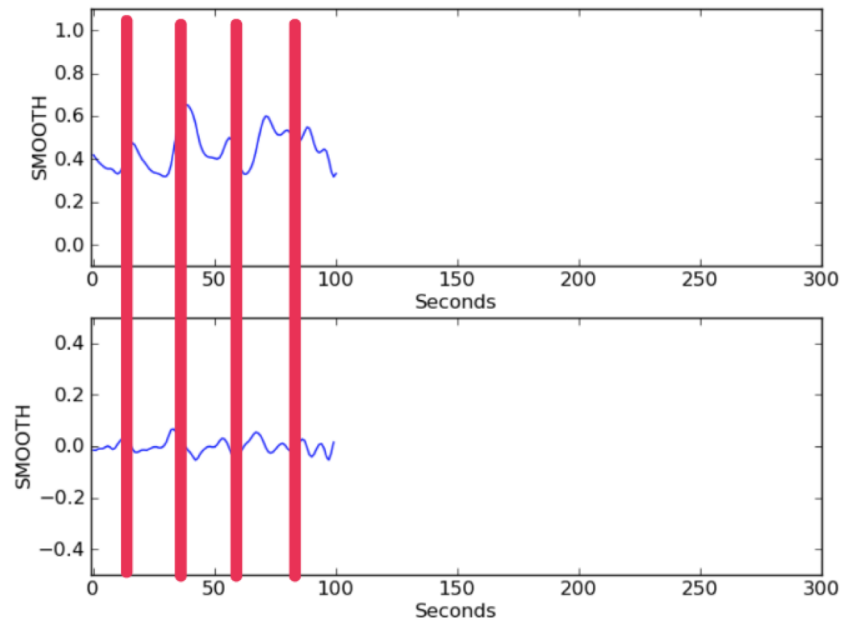
PAA

Piecewise Aggregate Aproximation
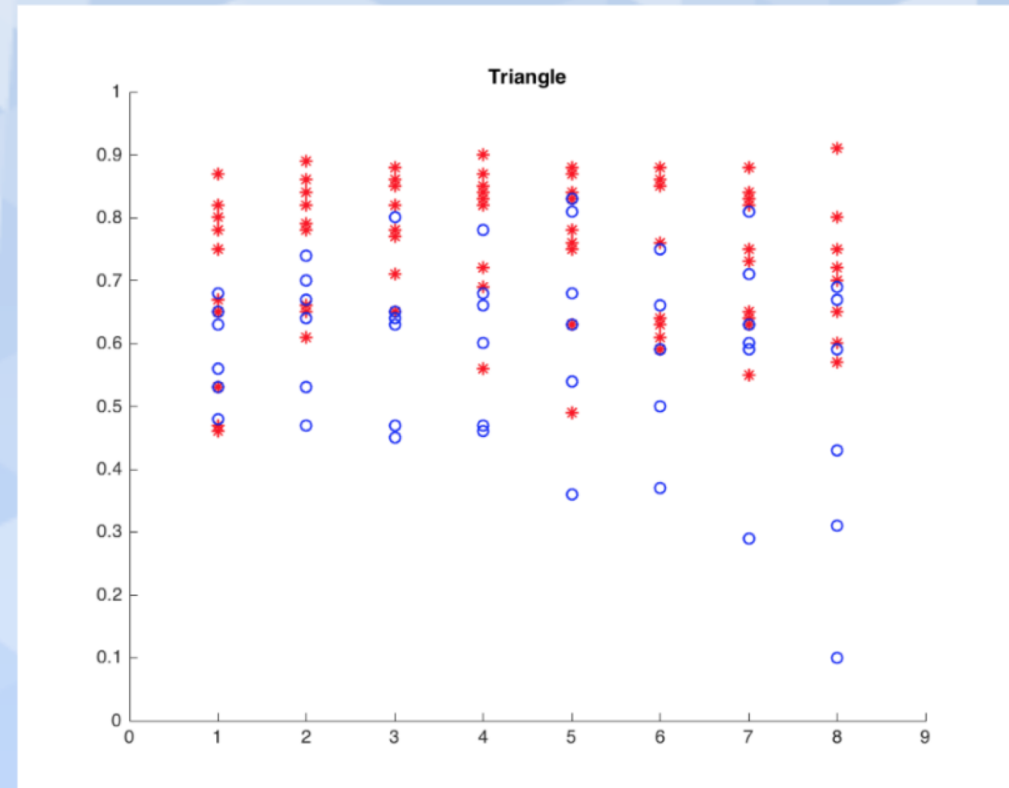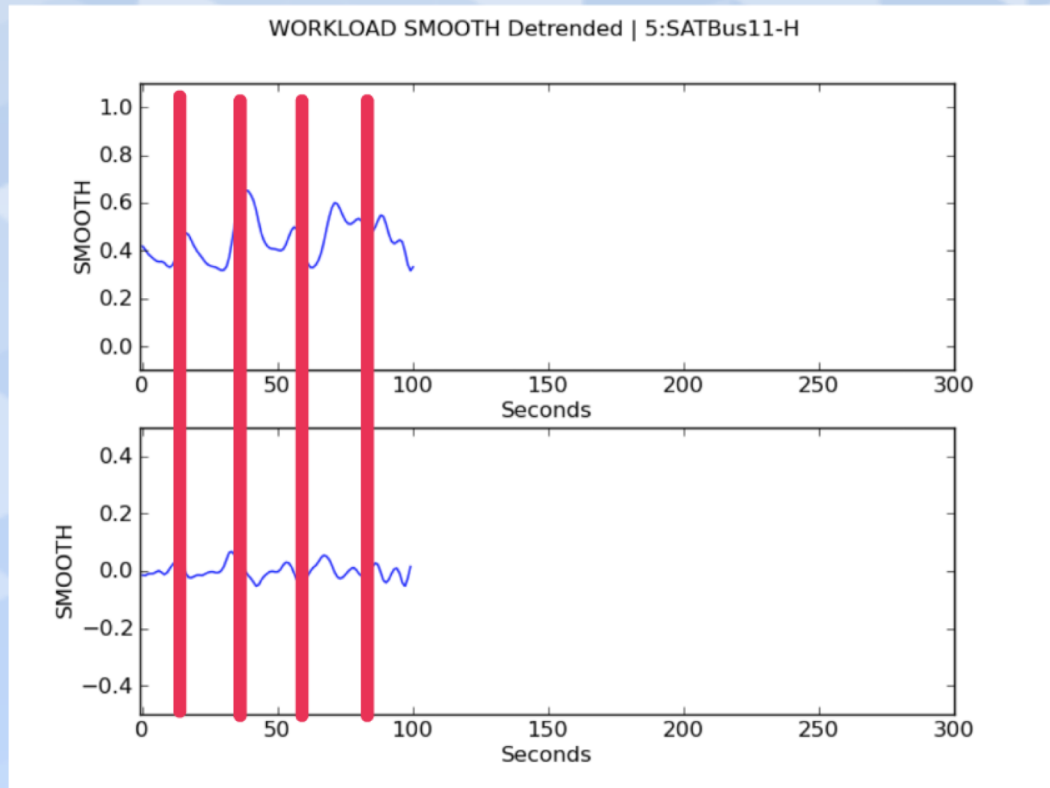
Results

Problem	Type	Readability level	Average response time (seconds)		Classification Accuracy (random sampling)	
			English Primary	English Learner	AdaBoost	Class.Tree
Bows	Easy	12	105	147	0.67	0.84
Classroom	Easy	12	123	149	0.49	0.50
Summation	Easy	2	46	45	0.58	0.58
Village	Easy	4	202	126	0.46	0.42
Bus	Hard	8	115	130	0.78	0.94
Fence	Hard	12	270	206	0.54	0.45
Towns	Hard	6	236	189	0.69	0.72
Triangle	Hard	6	282	260	0.75	0.72

Security

EEG signal processing for user authentification

- Signal recording with EMOTIV+
    - Free Software version
    - Mensual suscription with vendor
- First steps