

Problem Definition

OUTPUT SPECIFICATION

The dynamics of one individual's behavior during an exercise session are captured by the level of frustration experienced by the user at each exercise.

NASA TLX
Task Load Index

NASA Task Load Index

Frustration : "How insecure, discouraged, irritated, stressed, and annoyed were you?"

INPUT SPECIFICATION

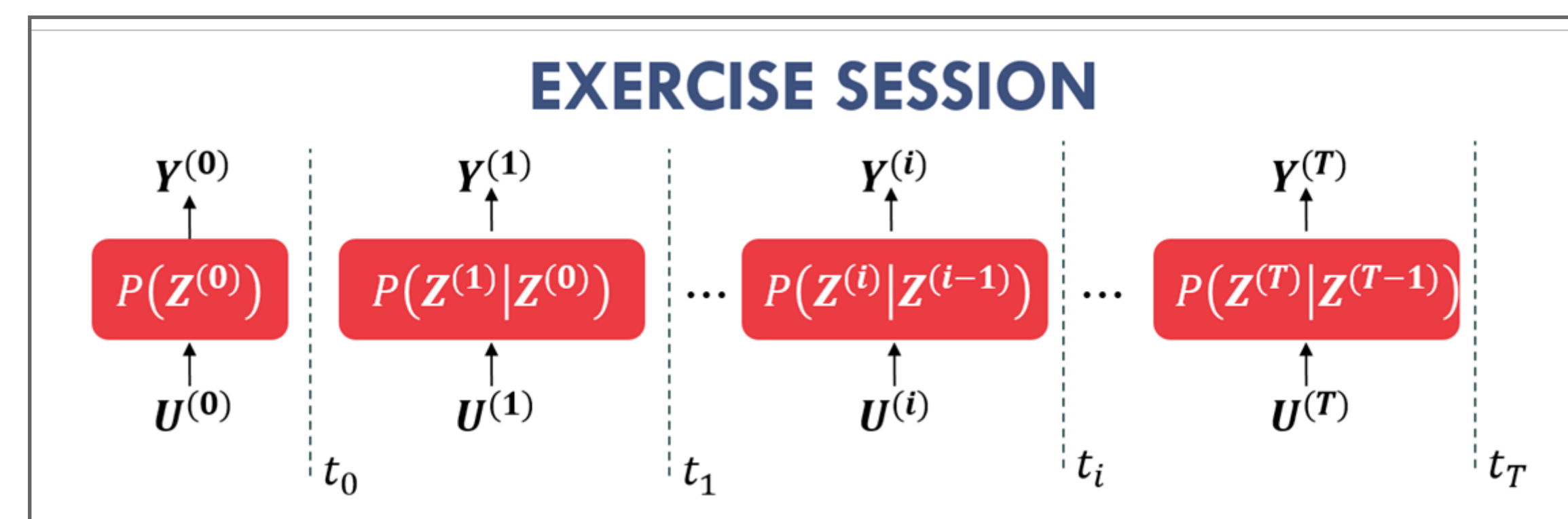
DYNAMIC

- Symptoms
- Stress
- Re-instructions
- Adherence to Instructions
- Performance
- Exercise Type

STATIC

- Disease Status
- Symptoms Baseline
- Experience with Technology
- Health/Disease Belief/Perception

Problem Formulation



The state of the system at time t is represented by a set of random variables:

$$Z^{(t)} = \{U^{(t)}, X^{(t)}, Y^{(t)}\}, t = 0, \dots, T$$

$U^{(t)}, X^{(t)}, Y^{(t)}$: Input, hidden and output variables of the model

ASSUMPTIONS

Markov Assumption $Z^{(t+1)} \perp Z^{(0:t-1)} | Z^{(t)}$

$$P(Z^{(0)}, Z^{(1)}, \dots, Z^{(T)}) = P(Z^{(0)}) \cdot P(Z^{(1)}|Z^{(0)}) \cdot \dots \cdot P(Z^{(T)}|Z^{(T-1)})$$

Time Invariance $P(Z^{(t)}|Z^{(t-1)}) = P(Z'|Z) \forall t > 0$

DYNAMIC BAYESIAN NETWORK

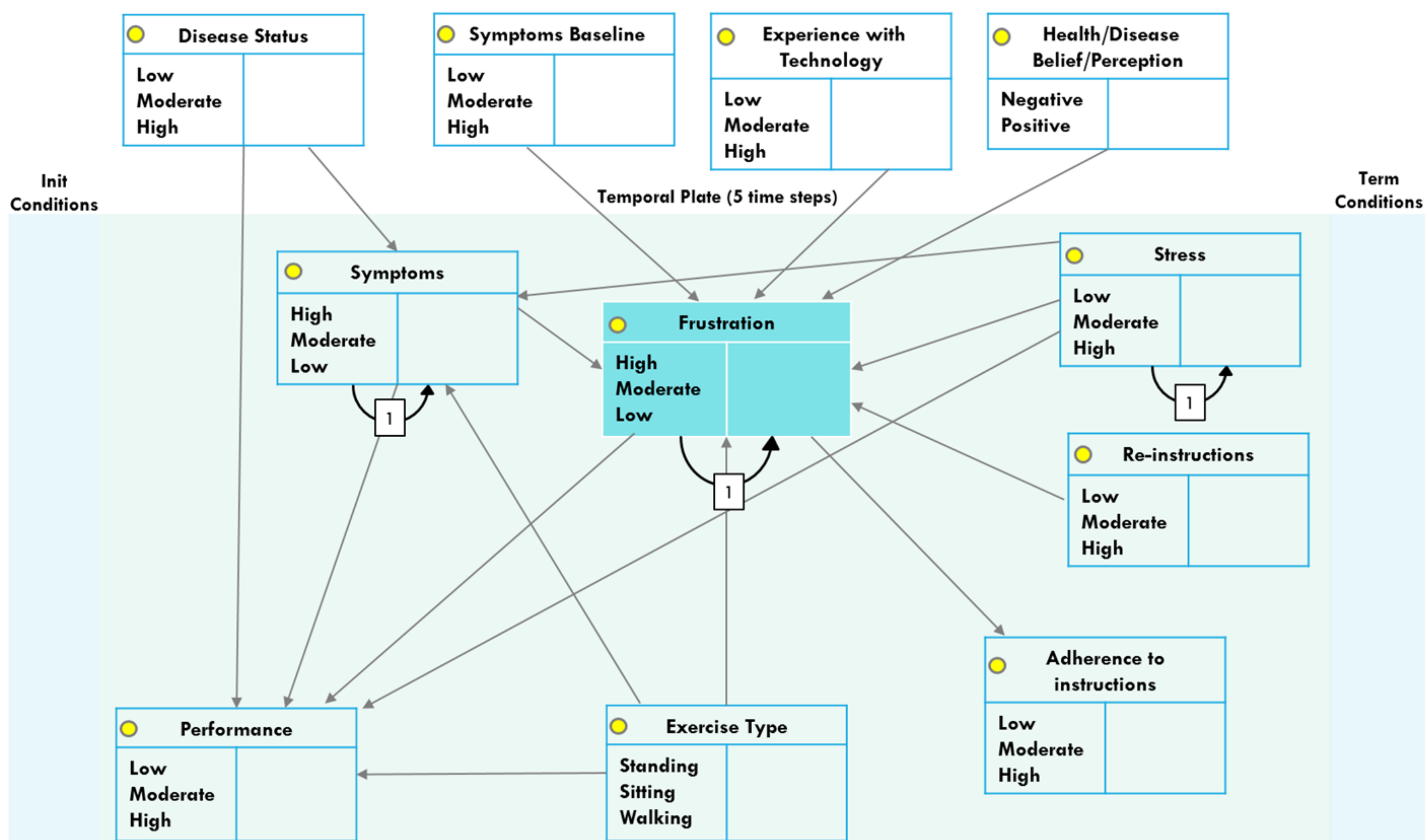
Initial state distribution $P(Z^{(0)})$

Transition model

$$P(Z^{(t)}|Z^{(t-1)}) = \prod_{i=1}^n P(Z_i^{(t)} | Par(Z_i^{(t)}))$$

Methodology

HOLOBALANCE Dynamic Bayesian Network



OUTPUT - Frustration

Frustration is defined as a 3-level variable:

High | Moderate | Low

INFERENCE

Estimation of the probability of Frustration given the evidence (e) of observed dynamic or static data.

$$P(\text{Frustration}|e)$$

Step 1 Specification of the state space $Z^{(t)}$ of the system

Step 2 Specification of the structure of the DBN

Step 3 Initialization of the state distribution $P(Z^{(0)})$ and the conditional probability $P(Z^{(t)}|Z^{(t-1)})$ (M_0)

Step 4 Parameter learning: Expectation-Maximization (EM) learning (Model M_{EM})

Step 5 Inference – The Clustering algorithm

Step 6 Evaluation – Evaluation of the classification performance of M_{EM} based on 10-fold cross-validation

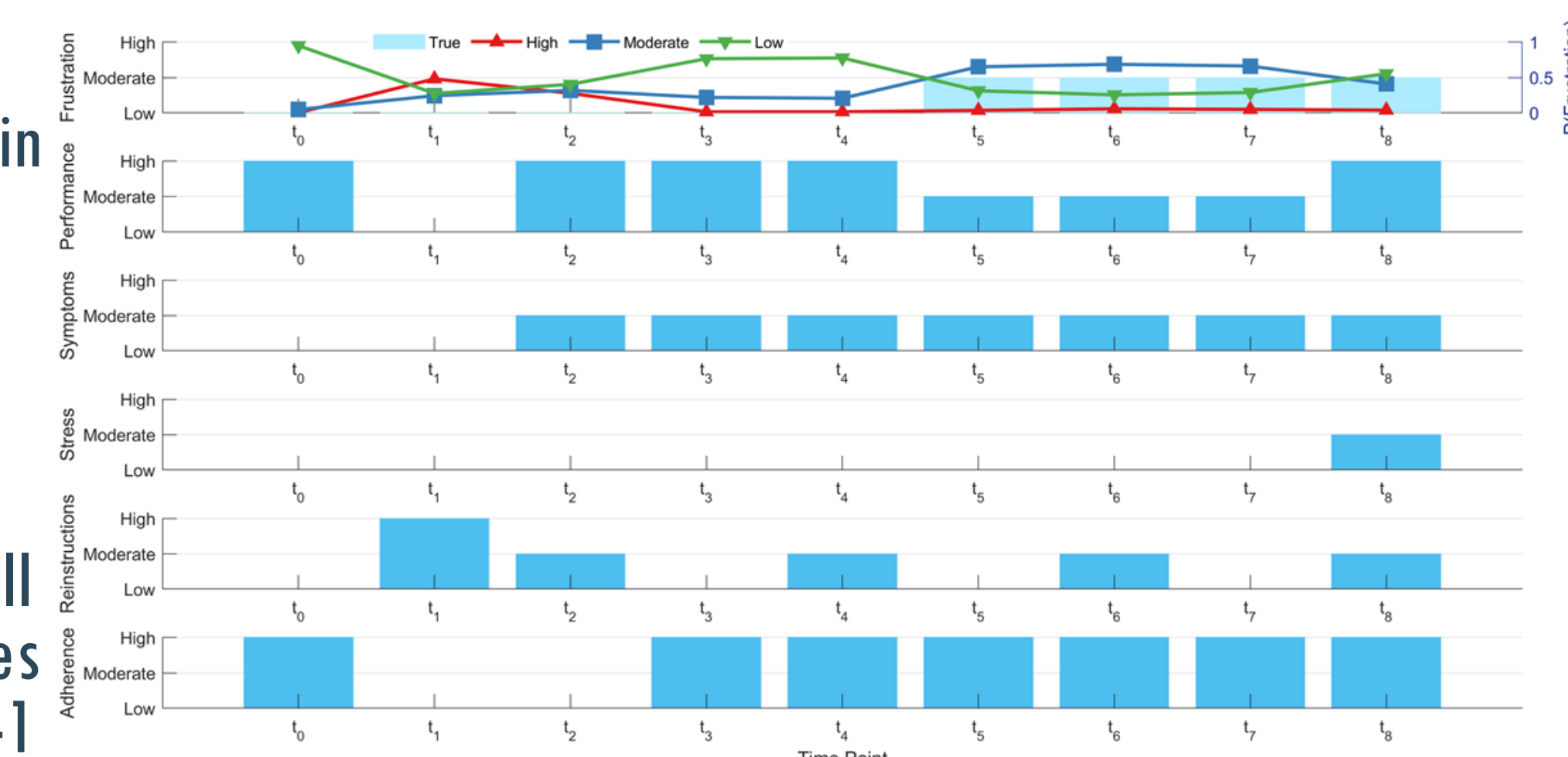
References

- <https://humansystems.arc.nasa.gov/groups/TLX>
- K. Murphy, Machine Learning: A Probabilistic Perspective, The MIT Press, 2012
- Lin & Druzdel, Uncertainty in Artificial Intelligence Conf., 1997
- Yuan & Druzdel, Uncertainty in Artificial Intelligence Conf., 2003
- GeNle Modeler, SMILE Engine, BayesFusion, LLC, <http://www.bayesfusion.com/>

Results

Testing the inference performance of the initial DBN model M_0

SUBJECT 1 Experience with Technology: Low | Disease Status: Low | Symptoms Baseline: Low | Health/Disease Belief/Perception: Positive



Subjects:
Data from 5 subjects in Athens

Procedure:
Each patient performed up to 36 exercises which are all the flowchart exercises with progressions (141 executed exercises in total)

Patients used Holobalance sensing module

Video capturing

Frustration was asked after exercise performed

