Data ➡ [Machine learning] ➡ Extracted Knowledge

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Predictive Analysis– I / IV

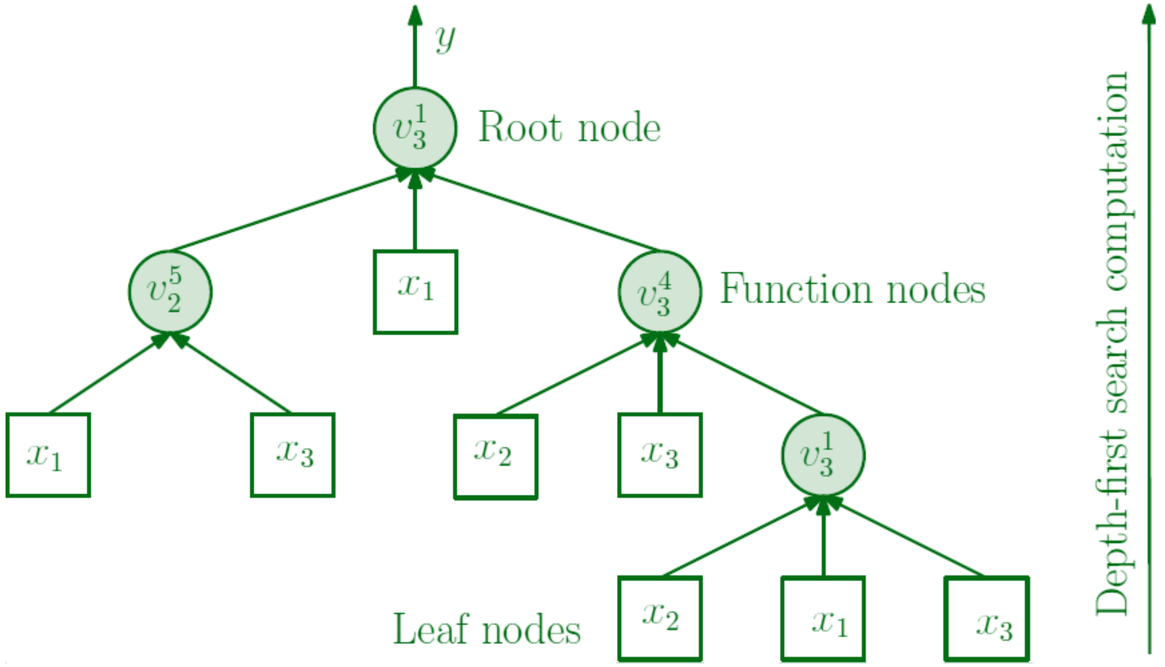


Fig. Typical Neural Tree

Neural Tree: A simplified and advanced variant of Neural Networks

- Adaptive Predictive Model
- Low Complexity Models
- Dimensionally Reduction (Feature Selection and Feature Analysis).
- Application: Time-series, binary classification, regression

Predictive Analysis – II / IV

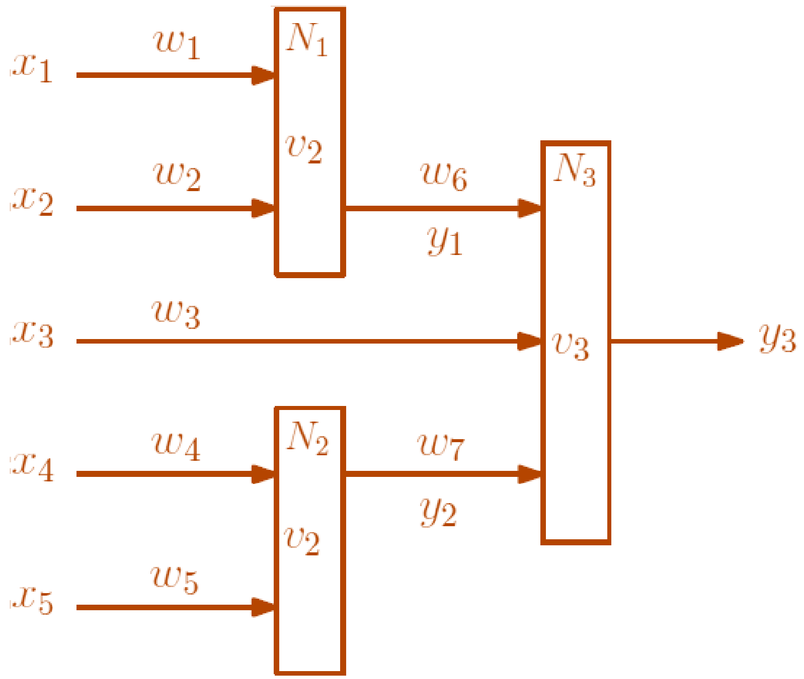


Fig. Hierarchical Fuzzy Inference System

Fuzzy Tree: An advanced variant of Fuzzy Inference Systems

- Adaptive Inferential Predictive Model
- Low Complexity Models
- Dimensionally Reduction (Feature Selection and Feature Analysis).
- Application: Time-series, binary classification, regression

Predictive Analysis – IV / IV

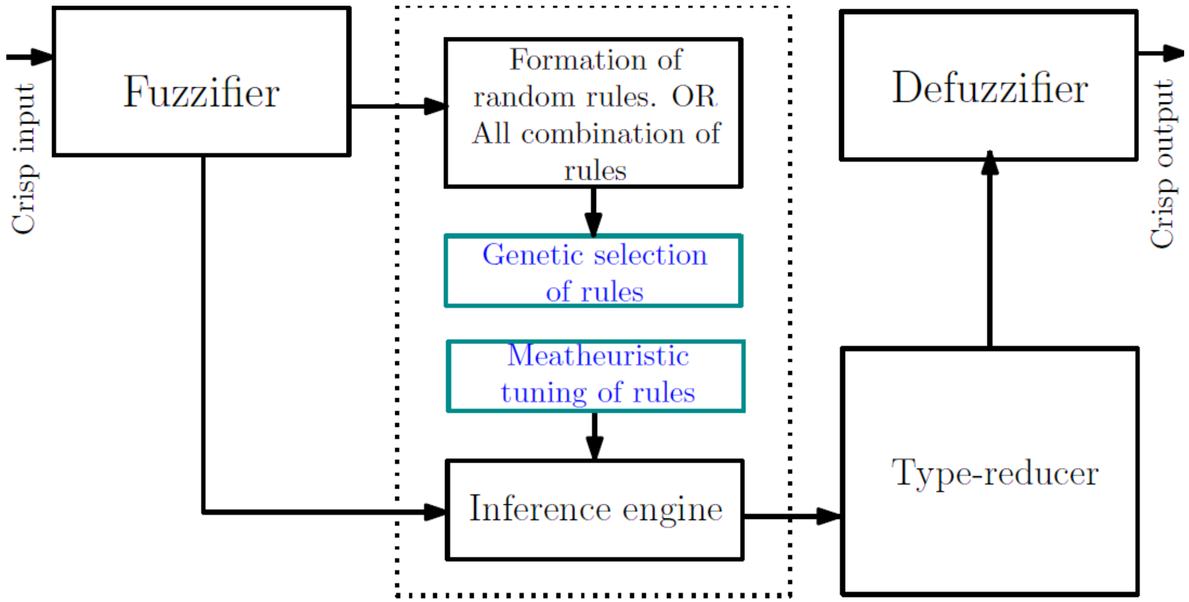


Fig A. Metaheuristic Optimization of Type-2 Fuzzy Inference System

Type-2 Fuzzy Inference System: For rule based predictive models

- **IF X** is **A** AND **Y** is **B** **THEN Z** is **C**
- C is a fuzzy set in Mamdani-FIS and a function in TSK-FIS
- Application: predictive analysis, multi attribute decision making

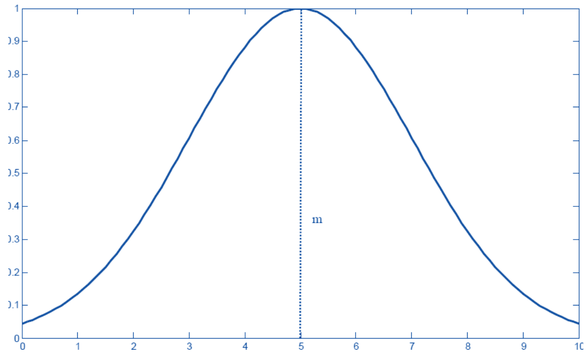


Fig B. Type -1 Fuzzy Set

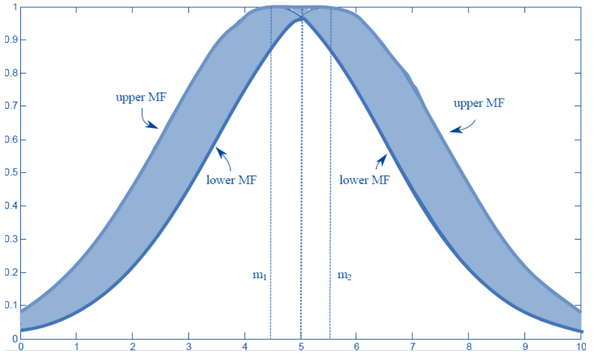


Fig C. Type -2 Fuzzy Set

Descriptive Analysis – I / V

Pattern Analysis and Clustering:

- Human Activity Recognition
- Hesitant Fuzzy Inference
- Associative Rule Mining
- Anomaly Detection
- Self Organizing Map (SOM)
- Evolutionary Feature Selection

Image Processing:

- Deep Learning: Convolutional Neural Network (CNN)
- Image Recognition (E.g., face, emotion, fingerprint detection)
- Image Pattern Matching
- Image Segmentation

Descriptive Analysis – II / V

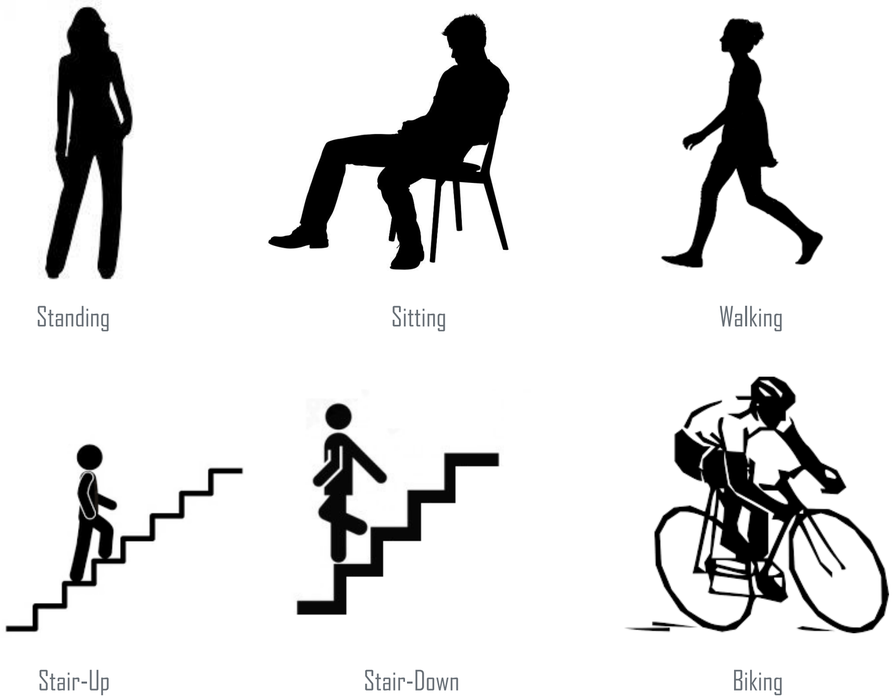


Fig A. Human Activities (For Illustration purpose)

Human Activity Recognition: For analyzing human activities based on the data collected from the smartphone, smartwatch, and smart-wear.

-Temporal Eco-State Recurrent Network was trained to classify activities.

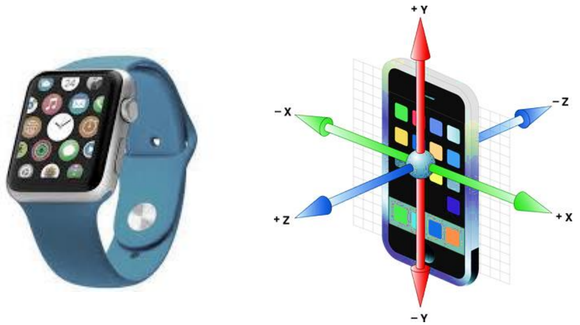


Fig B. Smart Watch and Gyroscope Sensor (Symbolic picture)

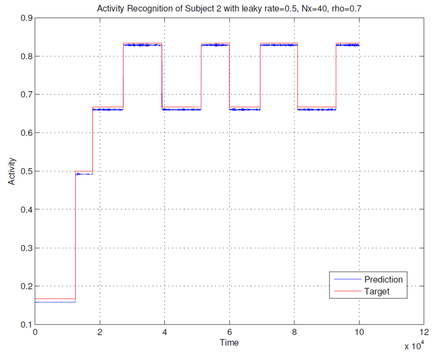


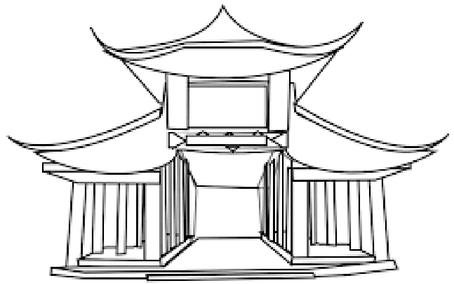
Fig C. : Target and Predicted result of our algorithm

Descriptive Analysis – III / V

Model A

Model B

Model C



Model D

Fig. Four models (symbolic) for experts evaluation and ratings.

Hesitant Fuzzy Inference System: For Multi Attribute/Criteria Decision Making

1. Determining multiple criteria for model evaluation (e.g., height, location, color, look, etc.)
2. Assign initial weights to criteria based on experts' knowledge
3. Assign linguistic terms (very poor, poor, average, good, very good) to each criteria.
4. Compute hesitant fuzzy set for each model and each criteria.
5. Optimize weights assigned to each criteria
6. Compute score to each models

- **Example answer: B < D < A < C**

Descriptive Analysis – IV / V

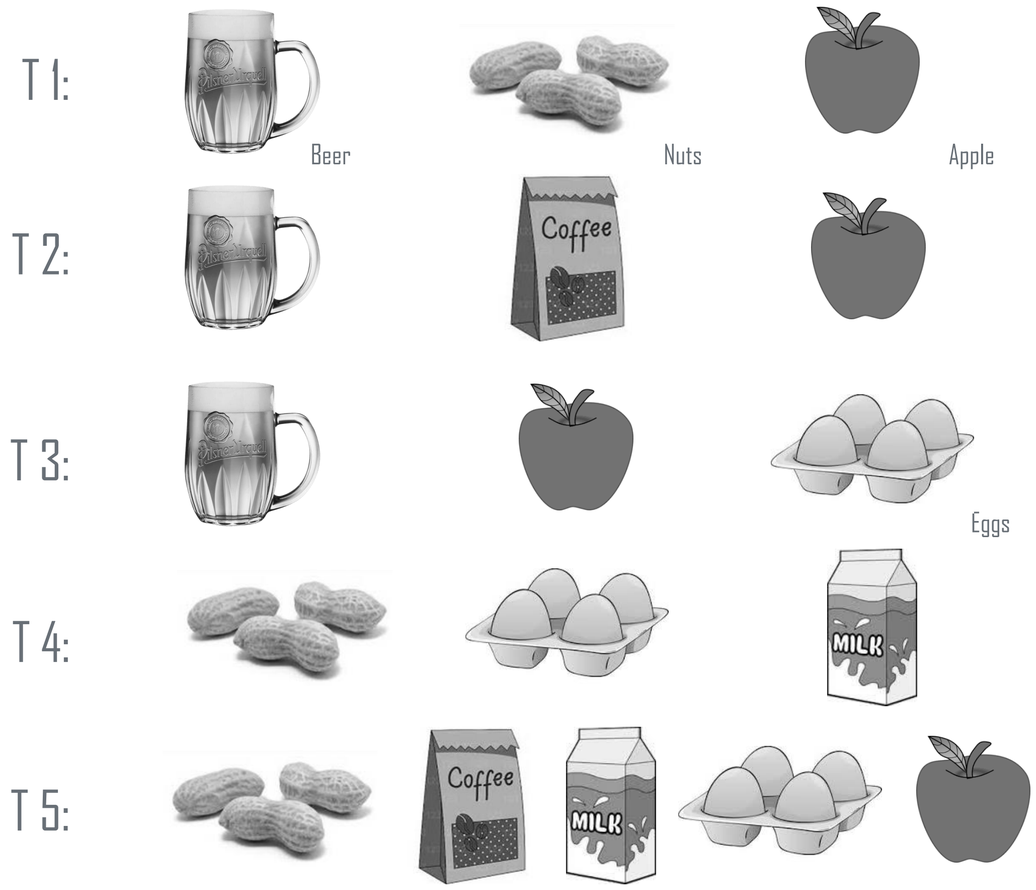


Fig. Shopping Example (for illustration purpose)

Associative Rule Mining: To find frequent pattern (rule) in dataset.

- **IF** someone buy an item X **THEN** what is the possibility that the person will by the item Y
  - So compute **X** → **Y** (Support, Confidence)
  - Support: The probability that transaction contain both X and Y
  - Confidence: The conditional probability that the transaction containing X also contain Y.
- For minimum support 50%
  - Frequent 1 item-sets: Beer: 3, Nuts: 3, Apple: 4, Eggs: 3,
  - Frequent 2 item-sets: {Beer, Apple}: 3
- For minim confidence 50%, the association rules are:
  - **Beer → Apple (60%, 100%)**
  - **Apple → Beer (60%, 75%)**

Descriptive Analysis – V / V

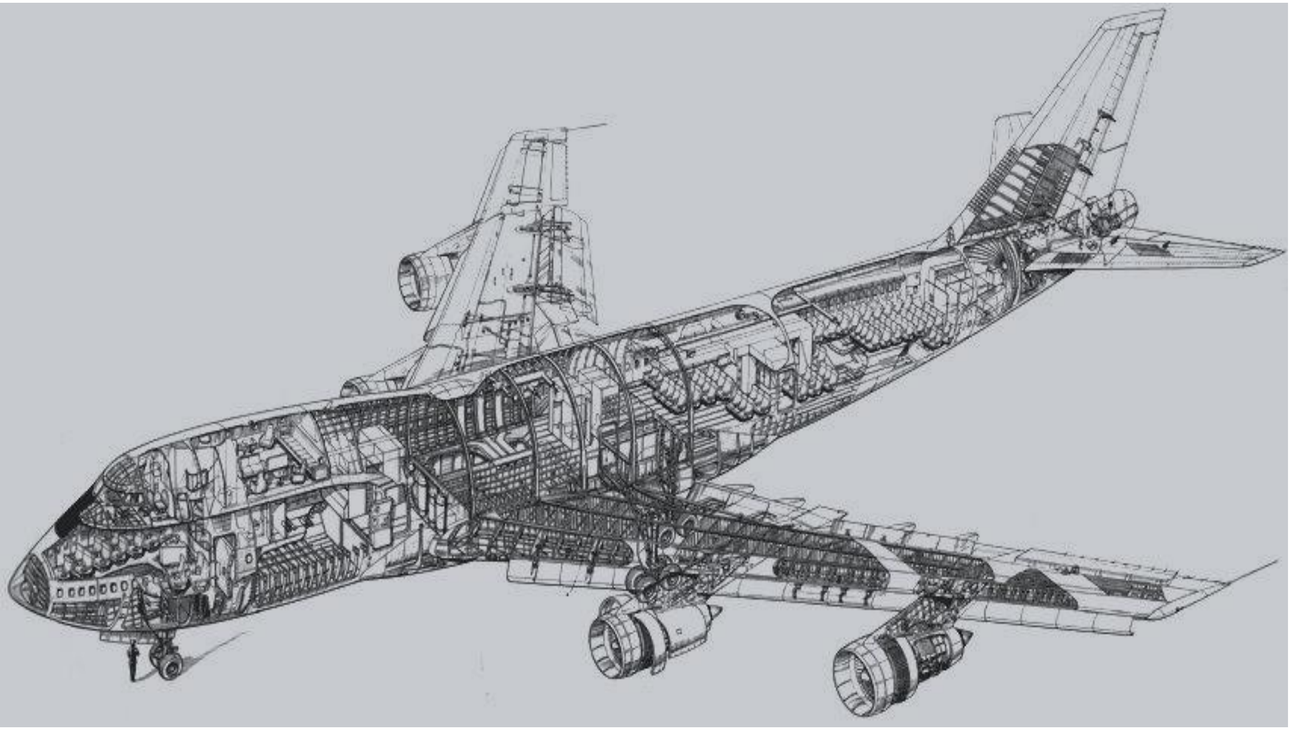
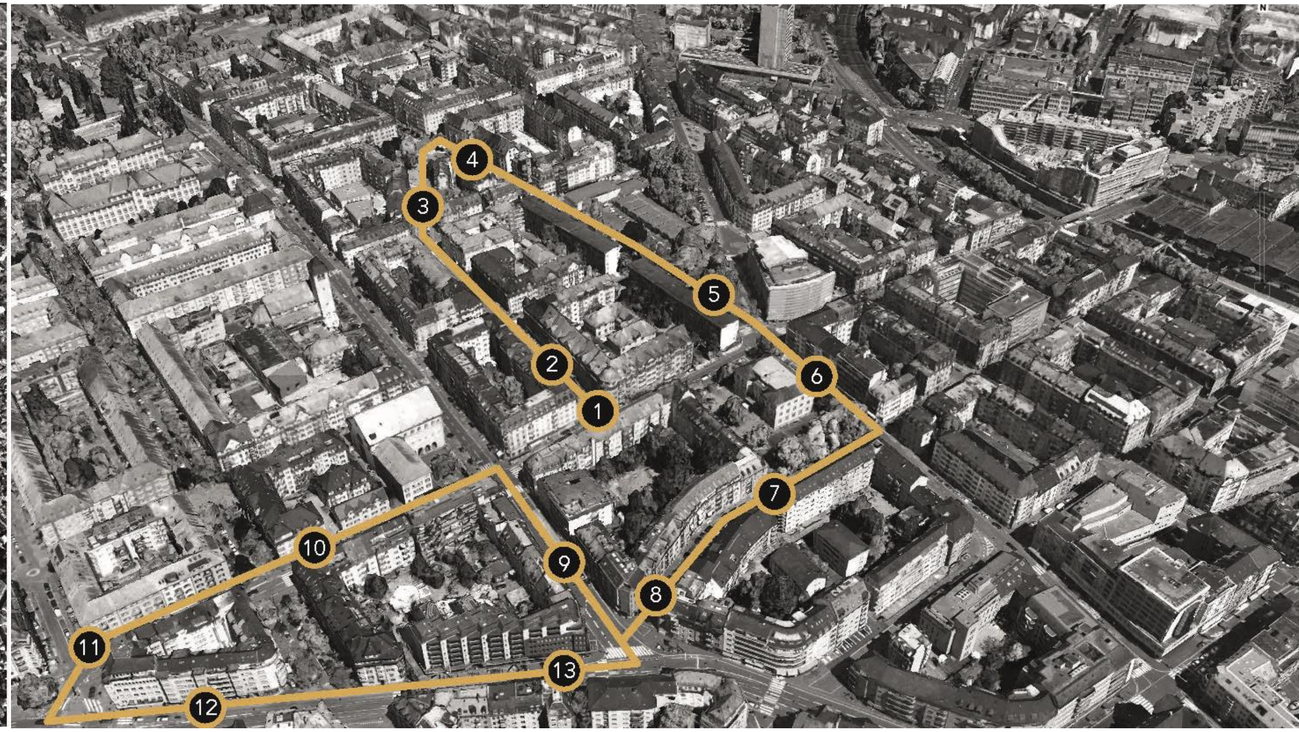


Fig. Boeing-747 has about **6** million parts, sensors, and functional units

Anomaly Detection: For detecting abrupt behavior of a system. Also known as outlier detection.

1. Determine positive functioning of target sensor (variables)
2. Label input vectors as positive or negative example
3. Train a model with al positive examples
4. Cross validated to determine a minimum threshold (say E)
5. Computer probability of a test vector: P(test vector)
6. **IF P(**test vector**) < E THEN** the test vector is anomalous.

ESUM: Analyzing trade-offs between the Energy and Social performance of Urban Morphologies



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ESUM – Data and its analysis steps

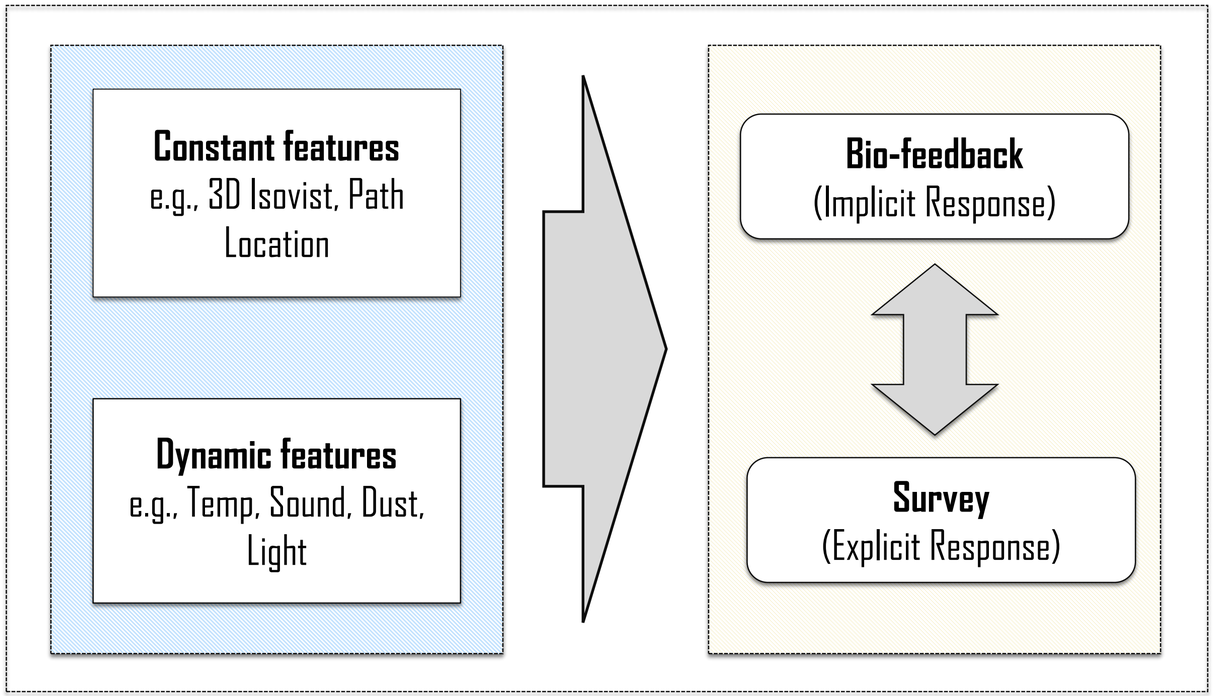

Fig F. Data dependencies in the ESUM project (illustration)

Data Analysis Steps Performed/Planned:

1. Automatic clustering using Self Organizing Map:
2. Neural Tree or NN: To finds if the participants behavior can be predicted. To perform Feature Selection and Analysis.
3. Fuzzy Tree or Fuzzy Inference Models: To find inferential (rule based) predictive models to understand if there are certain rule pattern emerge.
4. Evolutionary Feature Selection of Isovit Features
5. Associated Rule Mining: To find pattern in the relationship
6. To model survey questions as classification and fuzzy modeling.

Automatic clustering of participants data using SOM

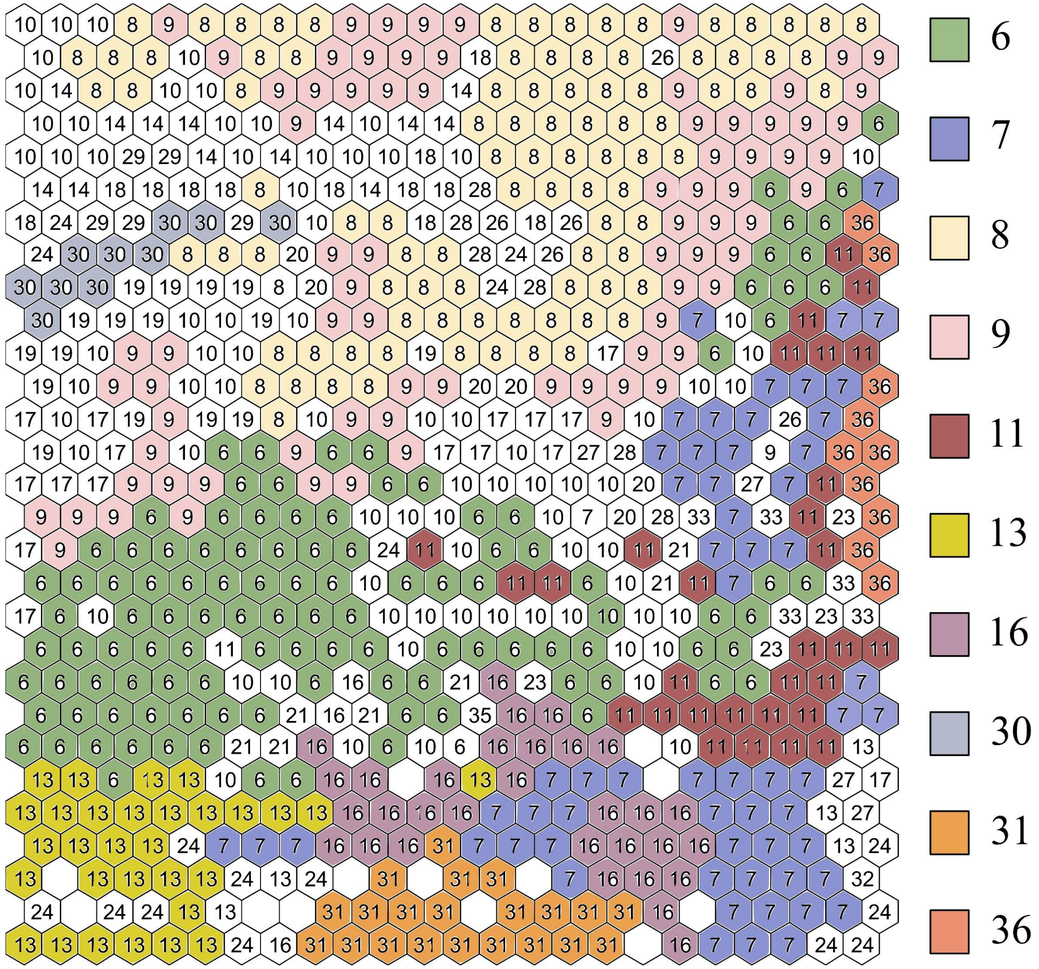

Fig. SOM clustering map of participants (indicated by numbers)

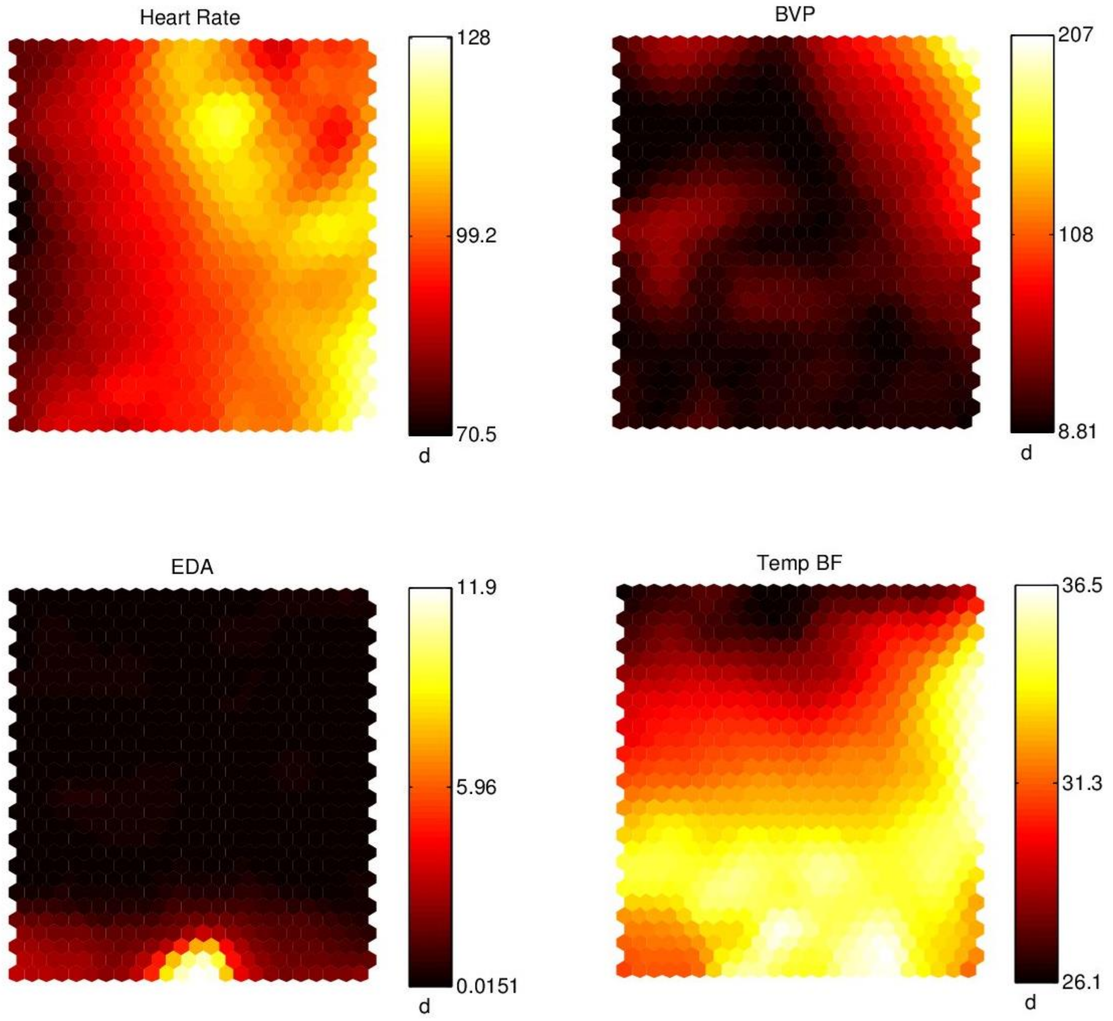

Fig. Changing of participants behavior – biofeedback responses

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ESUM – Predictive modeling (Non-inferential)

Assumption: Environment has direct influence on participants behavior.
Question: Can we predict the citizen's behavior based on certain environmental condition?

Case 1: Classification based predictive modeling results:

Hypothesis: If the environment has direct influence on the participants and the participants reacted differently the test classification accuracy will be high.

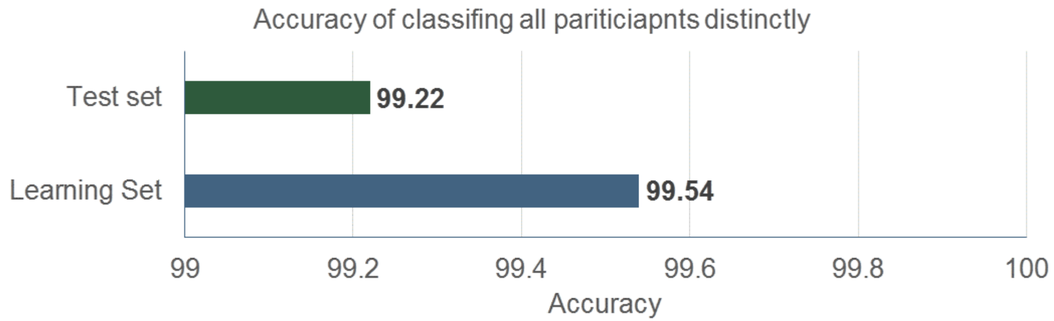

Fig A. Classification results of 10-fold cross validation

Case 2: Regression based predictive modeling results:

Hypothesis: If the environment has direct influence on the participants then the test correlation will be high.

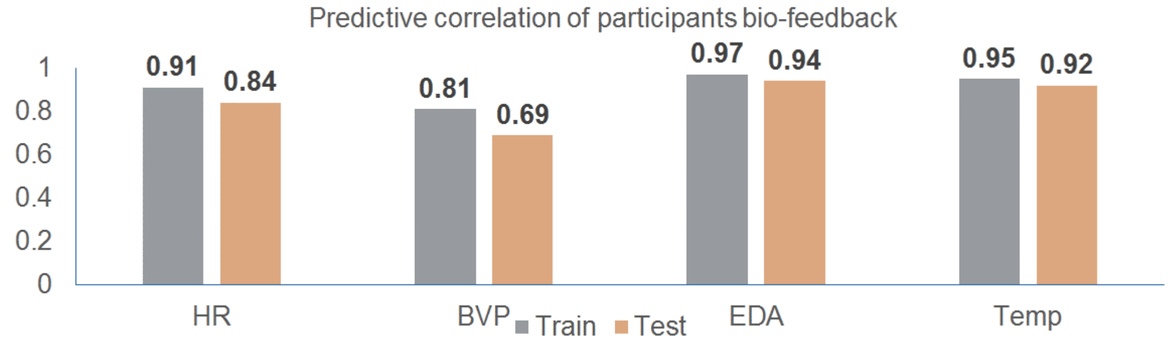

Fig B. Correlation coefficients of 10-fold cross validation

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ESUM – Feature Analysis

Question: What are the significant factor influence a citizen's behavior

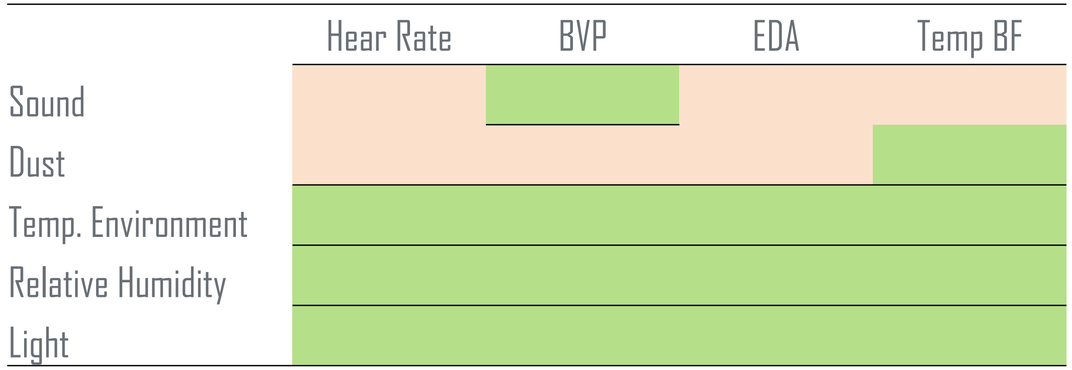
Case 1: Classification based feature analysis results.

Hypothesis: If the environment has direct influence on the participants, then the environment features should emerged prominent (high score) in feature analysis.

Selected Feature	Discarded Feature
Dust	Sound
Temp. Environment	Blood Volume Pressure (BVP)
Relative Humidity	
Light	
Heart Rate	
Electro dermal Activity	
Temp Biofeedback	

Case 2: Regression based feature analysis results.

Hypothesis: If the results of classification based feature analysis finds that the environment has direct influence on the participants, then, to find, which factors were significant towards measurements of HR. BVP, EDA, and TempBF is a significant step.



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ESUM – Predicting emotion of the citizens (Positive or Negative Emotion)

Question: Do the citizen's exhibits positive or negative emotion towards certain environment?

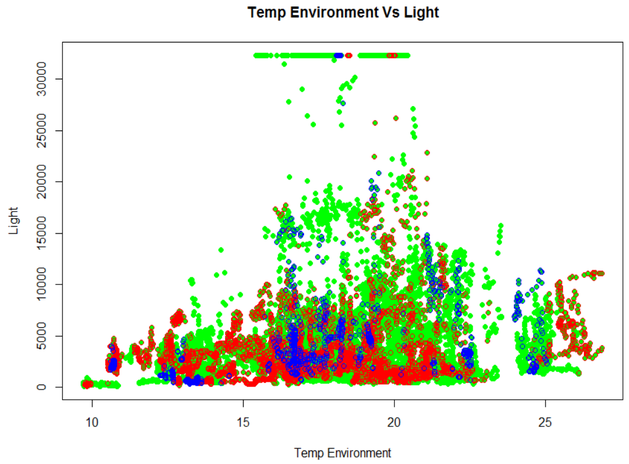
Case 1: Explicit response:

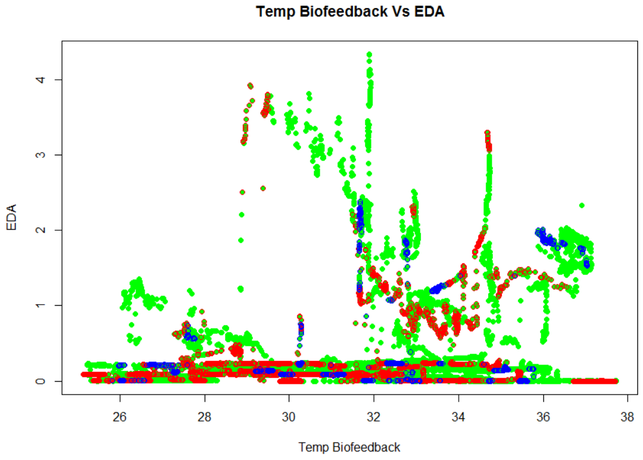
Response

Positive : 65.02%
Neutral : 05.99%
Negative : 28.97%

Emotion classification accuracy:

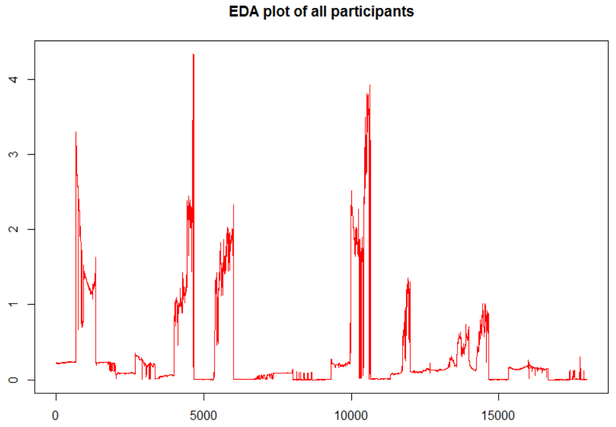
With only environment variables: 85.5%
With only biofeedback variables: 92.25%





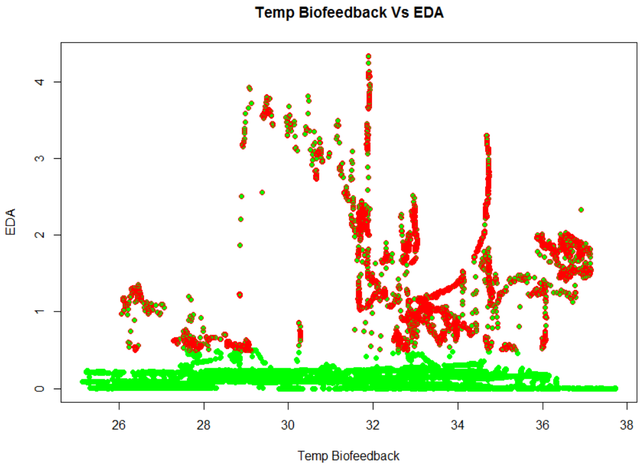
Case 2: Implicit response:

Fact:
A certain change (a peak) in EDA response causes higher stress (negative emotion)



Stress (feeling) as per EDA data

Positive : 81.37% (low stress)
Negative : 18.63%



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ESUM – Predictive modeling (Inferential)

Assumption: Environment has direct influence on participants behavior.
Question: Can we able to infer a detailed relationship between a citizens behavior and a city environment?

Fuzzy Inference model for emotional changes (specific study only)

Experiment: training a fuzzy rule learner (only for participants #.1.)
Inputs attributes: Sound, Dust, Temp EN, RH.
Output attribute: Emotion (Positive Negative, Neutral)
# of Samples: 667

Rule 1: **IF** Temp EN ≥ 13.08 **and** Light ≥ 1549.15 **THEN** Emotion is **Negative** (Cf = 0.83)

Rule 2: **IF** RH ≥ 46.902667 **THEN** Emotion is **Neutral** (CF = 0.58)

Rule 3: **IF** Temp EN ≤ 12.849018 **and** RH ≤ 46.7825 **THEN** Emotion is **Positive** (Cf= 0.81)

Cf indicates certainty factor

Interpretation (Inference)

Comments on participants #1 's emotion: Participant #1 feels comfortable under a lower temperature and a lower humidity.

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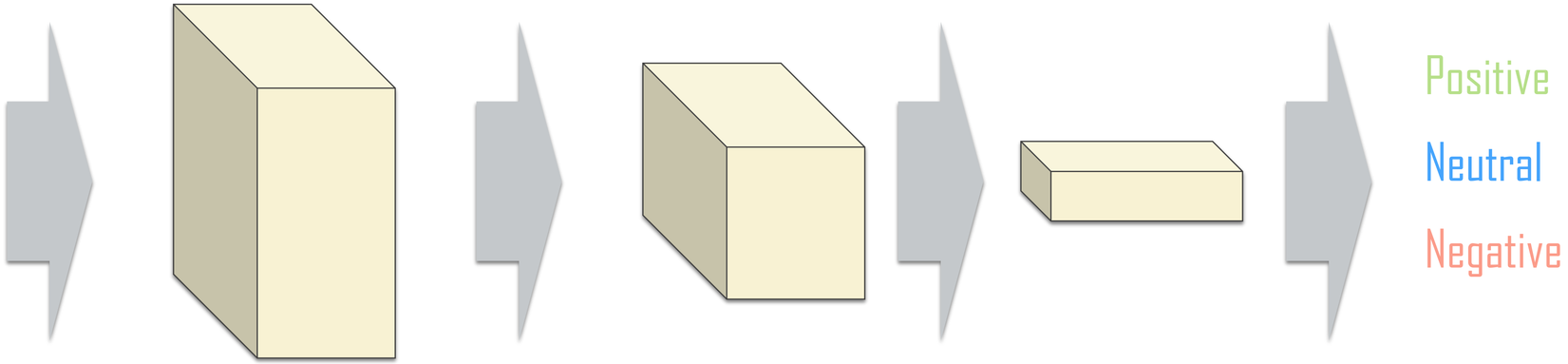
Another Idea: Deep learning (Convolutional Neural Network)

Multilevel stress labeling to the city images (or another from of architectural features) using EDA response/Survey response

224 x 224 image



Convolution
224x 224 x 10

Pooling
112 x 112 x 10

3-output fully
Connected NN layer

Positive

Neutral

Negative

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Thank You

What an optimization algorithm can do for us?

Genetic Algorithm: http://rednuht.org/genetic_cars_2/

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