Forecasting mood in bipolar disorder

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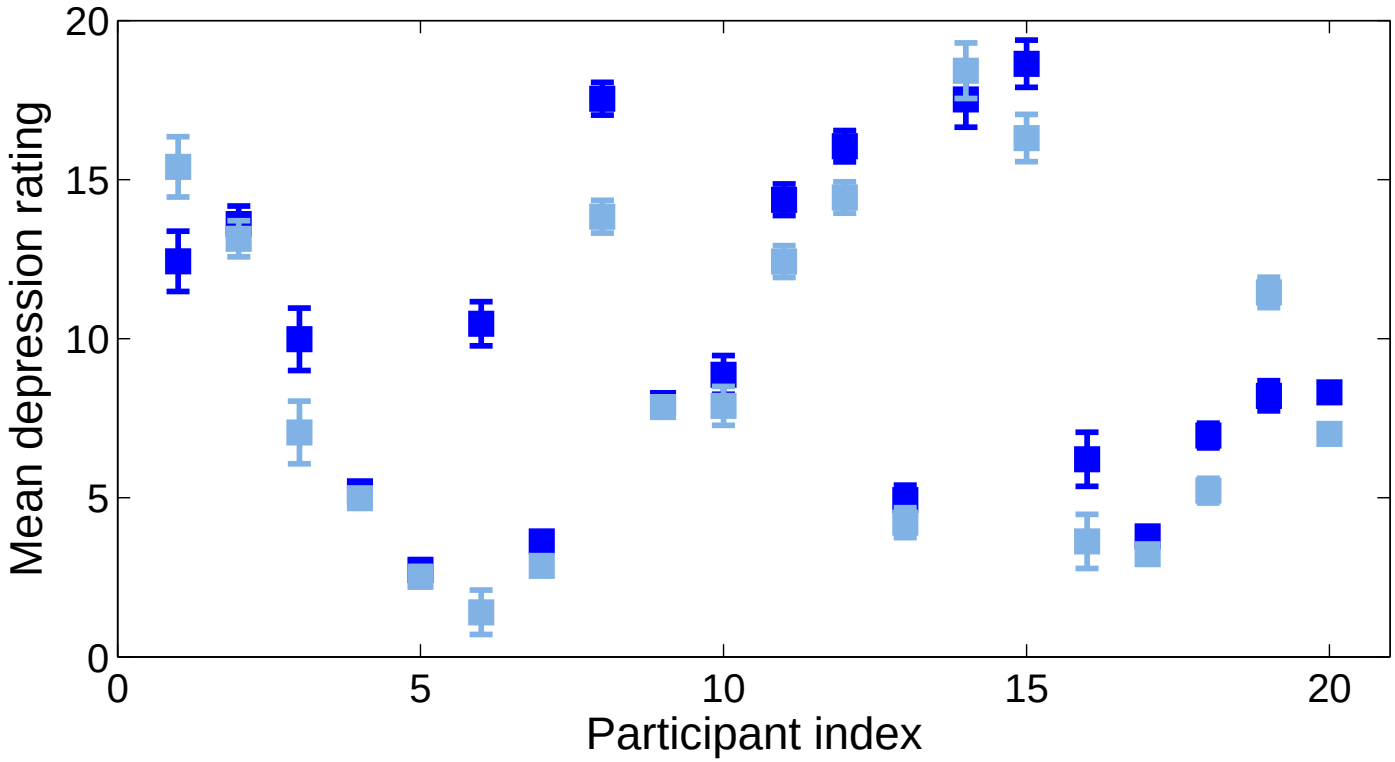
Outline

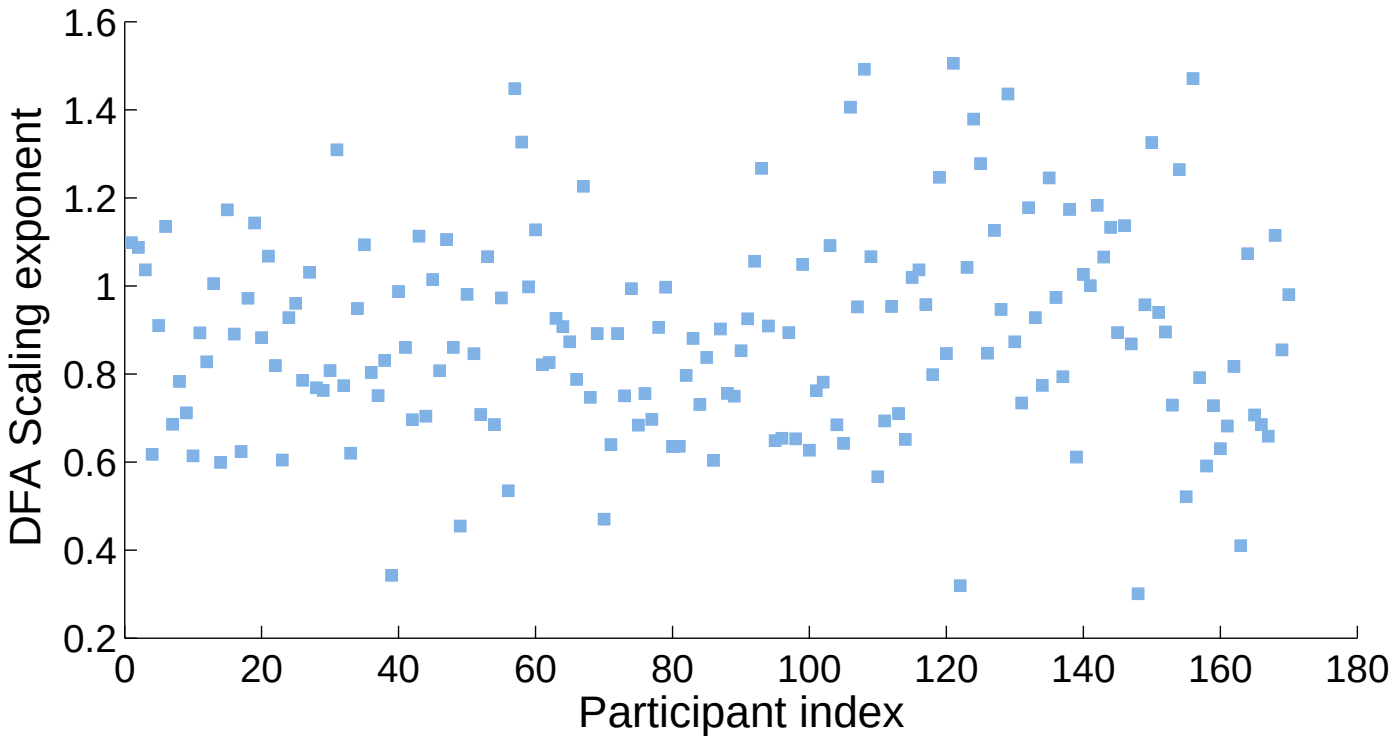
- Some qualities of the depression data - nonstationarity and a wide variation in roughness
- Forecasting depression using simple exponential smoothing and Gaussian process regression
- Effect of gender on forecastability
- A proposal for modeling with hidden Markov models

Non Stationarity of Time Series



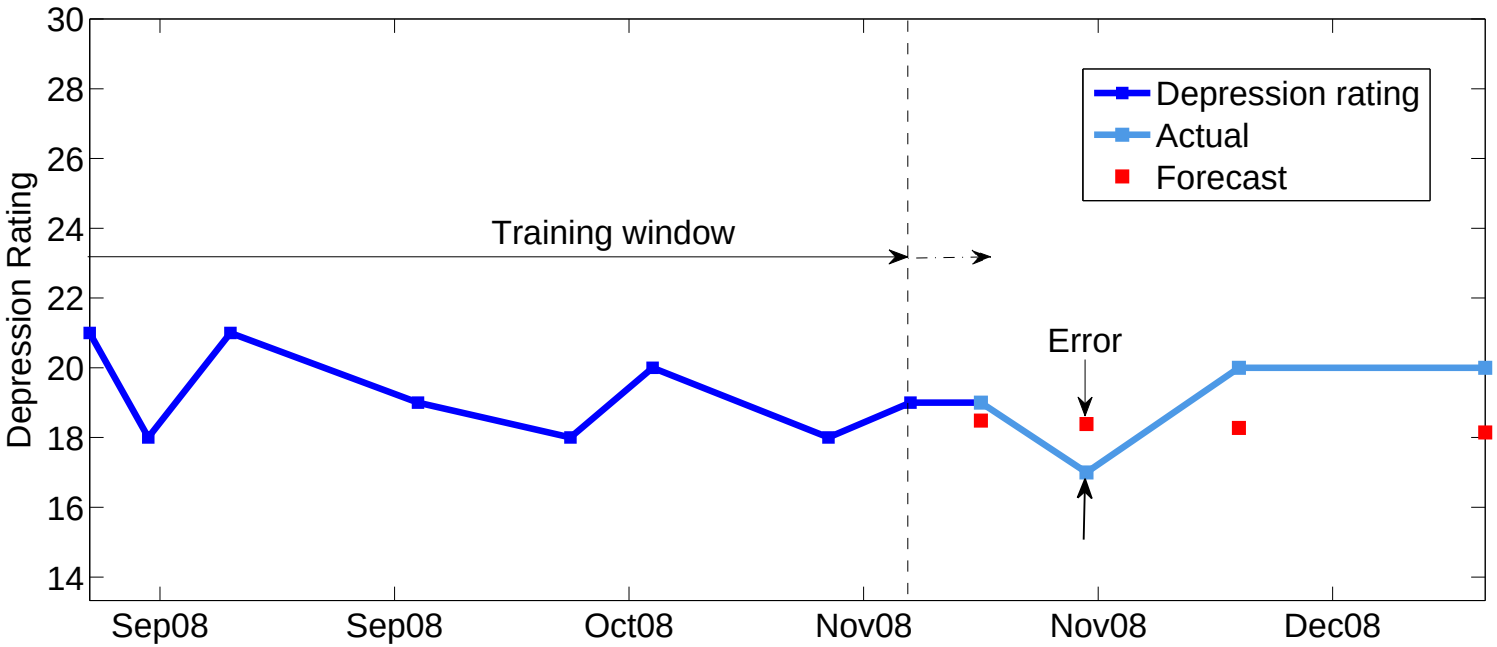
Dark blue and light blue markers represent the sample mean of the first and second halves of the depression time series for 20 patients. The error bars represent the standard error assuming that the numbers are Gaussian distributed and uncorrelated.

Roughness of time series



The scaling exponent provides a measure of the roughness of the time series. It can be seen that the data set is heterogeneous.

Forecasting Depression - method



For each time series, a window is extended stepwise from a minimum offset to a maximum length. At each point a next step forecast is made. This process is repeated for all patients, and the root mean square error taken over all forecasts.

Forecasting method 1 - exponential smoothing

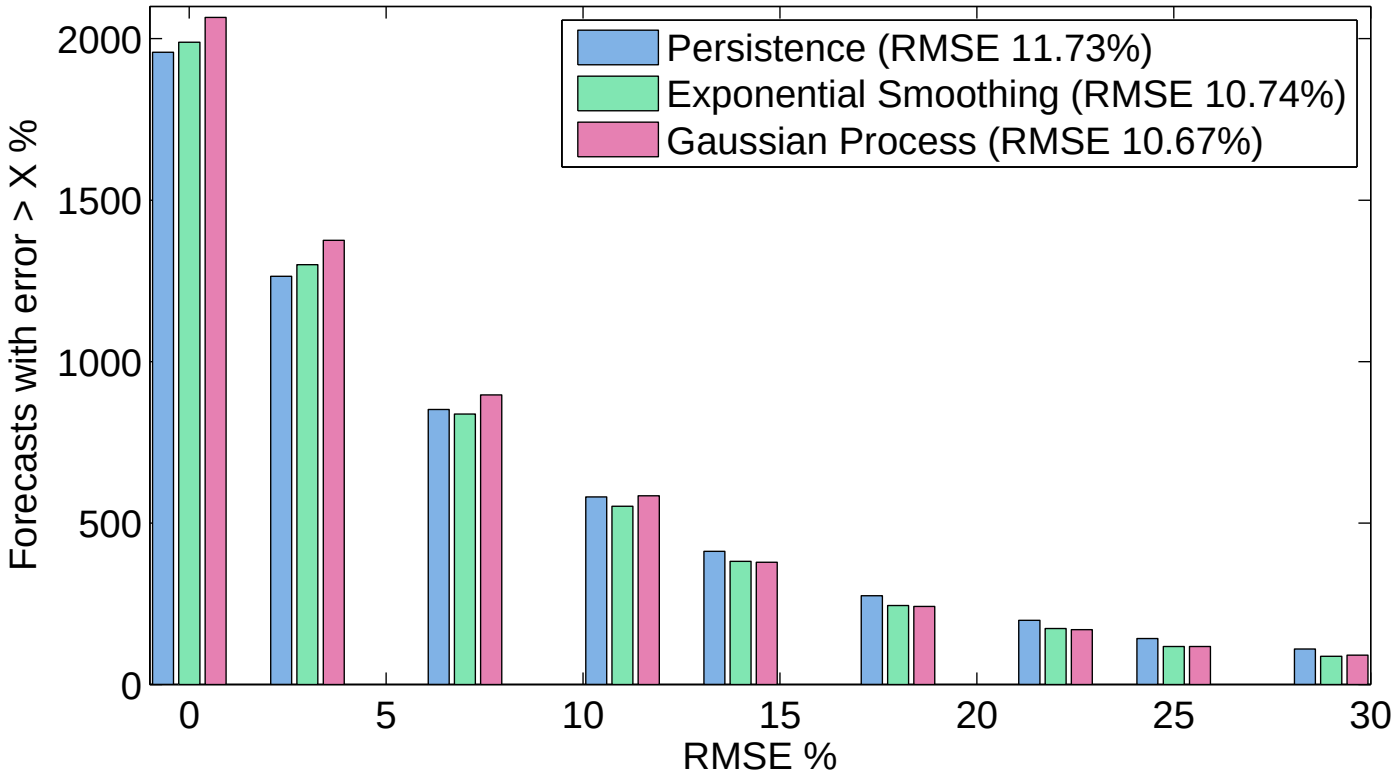
- Self esteem has been found to be modelled using simple exponential smoothing $\hat{y}_{t+1} = \hat{y}_t + \alpha(y_t - \hat{y}_t)$ (Fortes, *Dynamics of Self-Esteem and Physical Self, Quality and Quantity, 2004*).
- They suggest that two processes underlie the dynamics of self-esteem: *preservation* which tends to restore the previous value after a disturbance and adaptation, which tends to inflect the series in the direction of the perturbation
- The disturbance (or shock) can be interpreted as the outcome of stressors or positive experiences. The value of α might then provide a measure of the preservation/adaptation spectrum.

Forecasting method 2 - Gaussian process regression

- For a Gaussian Process the joint distribution between any finite number of these variables is Gaussian. The process is specified by a mean function and a covariance function.
- We postulate a certain form of parameterised covariance function and estimate the parameters from the data.
- The expected value and variance of the function can then be found for any input.

Forecasting Results

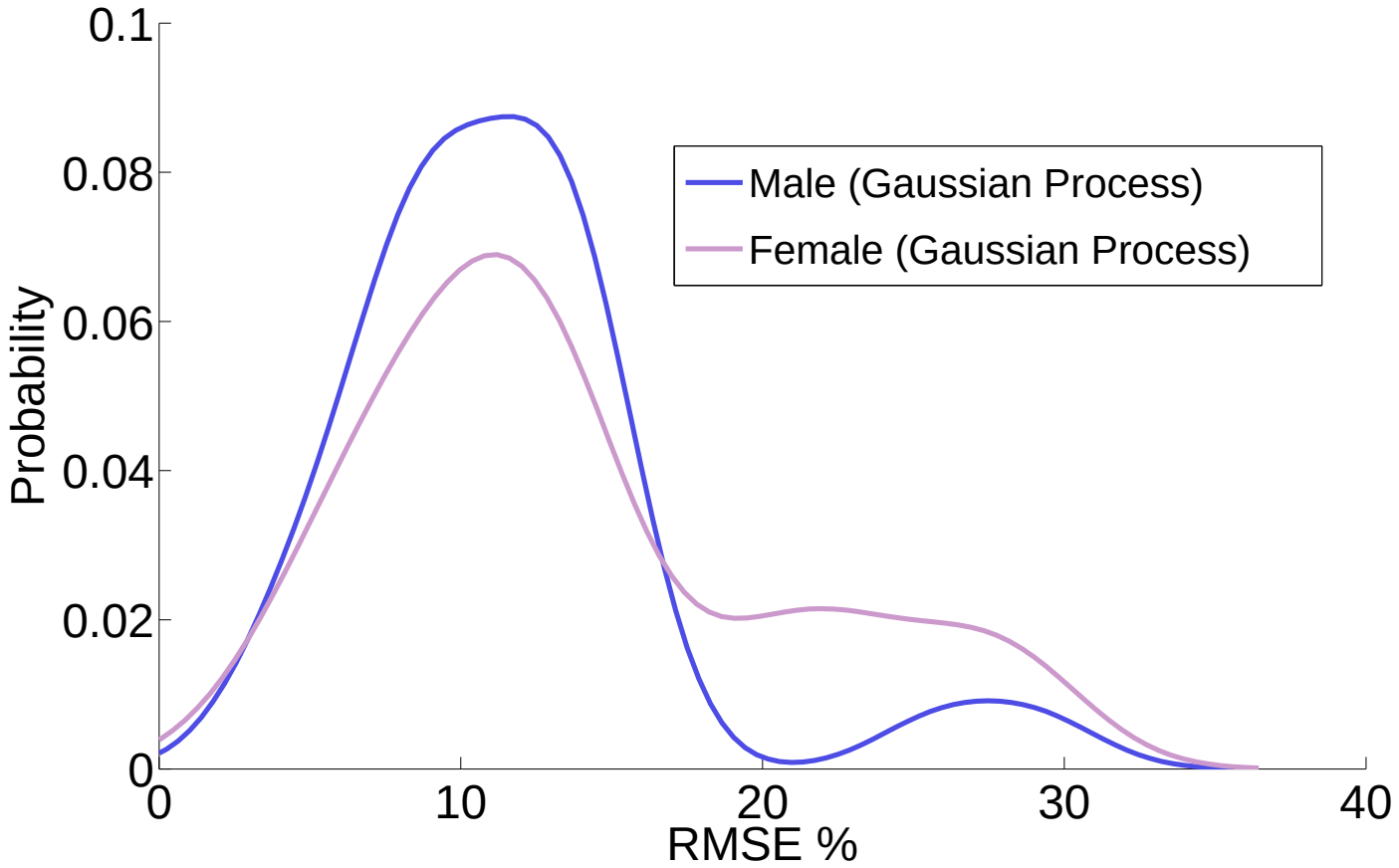
Cumulative error distribution



The figure shows the cumulative error distribution for 2440 forecasts. The X axis is the forecast error normalised by the maximum of the rating scale. There is little to choose between the methods, except that the nontrivial methods reduce higher errors slightly compared with persistence forecasting.

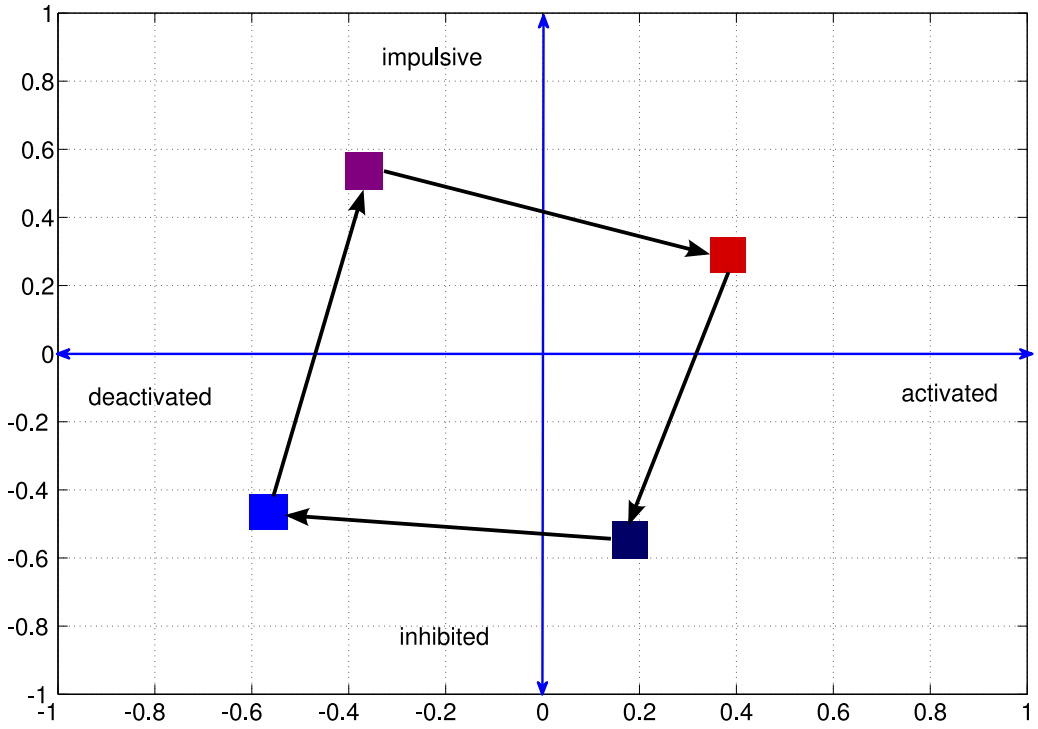
Gender Differences

Forecast error distributions for male and female patients



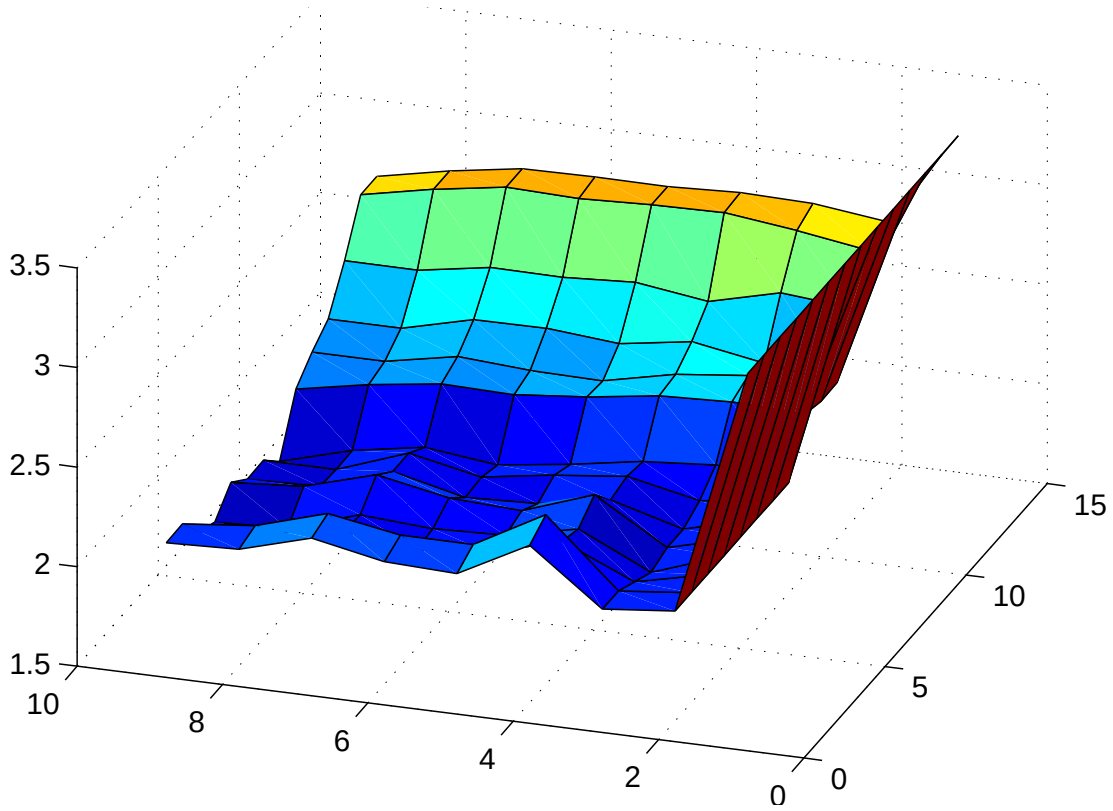
Kernel density estimation for distribution of forecast errors for two sets of 30 patients, one all male and the other all female ($p = 0.02$). The x-axis is the normalised RMS forecast error for a participant over a test set.

Hidden Markov modelling



A state space model of mood in bipolar disorder. Activation is measured along the x-axis and impulsivity is measured along the y-axis. The rectangles are representative points corresponding to mood episodes, and the path represents a mood trajectory. The proposal is to model each mood episode with a hidden Markov model which generates observation vectors.

Pattern recognition techniques



Currently working on an algorithm to build a library of mood patterns and to use these for forecasting. Results are so far little better than persistence forecasting, but there is potential for improvement.

Summary

- The mood dataset is heterogeneous with respect to stationarity and roughness.
- Exponential smoothing and Gaussian process forecasting offer little improvement over persistence forecasts for depression.
- A difference was found in the forecast error between sets of male and female patients.
- Proposals for work using hidden Markov models and pattern recognition.