Multiple Kernel Learning on the Limit Order Book

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Limit Order Books

Limit orders for a currency such as EURUSD (€/$) specify whether a party wishes to buy or sell the currency, the amount (volume) desired, and the price the transaction will occur at.

These orders are accumulated in a limit order book, with buy orders sitting on the Bid side and sell orders sitting on the Ask:

<table>
<thead>
<tr>
<th>Price</th>
<th>Volume($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4752</td>
<td>1</td>
</tr>
<tr>
<td>1.4751</td>
<td>8</td>
</tr>
<tr>
<td>1.4750</td>
<td>3</td>
</tr>
<tr>
<td>1.4749</td>
<td>15</td>
</tr>
<tr>
<td>1.4748</td>
<td>5</td>
</tr>
<tr>
<td>1.4747</td>
<td>9</td>
</tr>
</tbody>
</table>

We use the volumes sitting on the order book at time $t$, $V_t \in \mathbb{R}^6$, to predict what direction €/$ might move over a time horizon $\Delta t$, i.e. whether:

$$P_{t+\Delta t}^{Bid} > P_{t}^{Ask} \quad \text{or} \quad P_{t+\Delta t}^{Ask} < P_{t}^{Bid}$$
Experimental Design

Construct a set of features from $V_t$:

$$F = \left\{ V_t, \frac{V_t}{\| V_t \|_1}, V_t - V_{t-1}, \frac{V_t - V_{t-1}}{\| V_t - V_{t-1} \|_1} \right\}$$

combined with a set of kernels:

$$K = \left\{ \exp\left( -\frac{\| x_i - x_j \|_2^2}{\sigma_1^2} \right), \ldots, \exp\left( -\frac{\| x_i - x_j \|_2^2}{\sigma_3^2} \right), \langle x_i, x_j \rangle \right\}$$

The 24 feature/kernel combinations are used individually and through MKL methods of SimpleMKL and LPBoostMKL to train three SVM to predict direction of price movement over $\Delta t$:

SVM 1: $P_{t+\Delta t}^{Bid} > P_t^{Ask}$  \[ \Rightarrow y_t^1 = +1, \text{ otherwise } y_t^1 = -1 \]

SVM 2: $P_{t+\Delta t}^{Ask} < P_t^{Bid}$  \[ \Rightarrow y_t^2 = +1, \text{ otherwise } y_t^2 = -1 \]

SVM 3: $P_{t+\Delta t}^{Bid} < P_t^{Ask}$, $P_{t+\Delta t}^{Ask} > P_t^{Bid}$  \[ \Rightarrow y_t^3 = +1, \text{ otherwise } y_t^3 = -1 \]
Examples of Predictions and Profit & Loss Curve

![Graph showing price and profit over elapsed time. The graph includes lines for bid price, ask price, positive prediction, negative prediction, and zero prediction. Below, there are lines for SimpleMKL, LPBoost, Individual Kernel 1, and Moving Average, showing profit over elapsed time.]