Order Execution Strategies With Support Vector Machines

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Volume Weighted Average Price (VWAP)

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$$VWAP = \frac{\sum_{i=1}^{n} p(i)\, v(i)}{\sum_{i=1}^{n} v(i)}$$

$p(i)$ is a price of the i-th trade, $v(i)$ is a volume of the i-th trade

- - market VWAP n is a number of all trades in T period,
  - order VWAP n is a number of trades of the order o in T
- the popular measure of quality of executing o is the ratio order VWAP/market VWAP;
- for buy orders lower ratio is better
- the ratio equal to 1

VWAP, cont.

- consider dividing T to m-th T_i periods

Two Strategies of Optimizing the Ratio

- achieving the ratio equal to 1
- requires prediction of volume participation for every T_i
- volume participation for i-th time slice is $v(T_i)/v$

- achieving the ratio better than 1
- requires prediction of prices for every T_i

- the result of both strategies is volume of o divided among all time slices
- an additional strategy is needed for trading in every time slice

Predicting Volume Participation

- prediction strategies, predict volume participation
  1. for T_i as an average of previous values for the same time slice
  2. for T_i as a previous time slice T_{i-1} value
  3. for all T_i at once as the constant function
  4. for all T_i at once as the function based on historical data, using Support Vector Machines (SVM)
- volume of o divided accordingly to predicted volume participation
- expected lower variance of the final execution error for better method

Predicting Volume Participation using Support Vector Machines (SVM)

- a regression problem to solve
- Support Vector Regression used (ε-SVR and δ-SVR)
- additional constraint for the solution

$$\sum_{i=1}^{m} v\left(T_i\right) = 1$$

- adjusting b of the solution of SVM to satisfy the constraint

ε-Support Vector Regression Idea

- find a function for which all examples fall between ε bounds

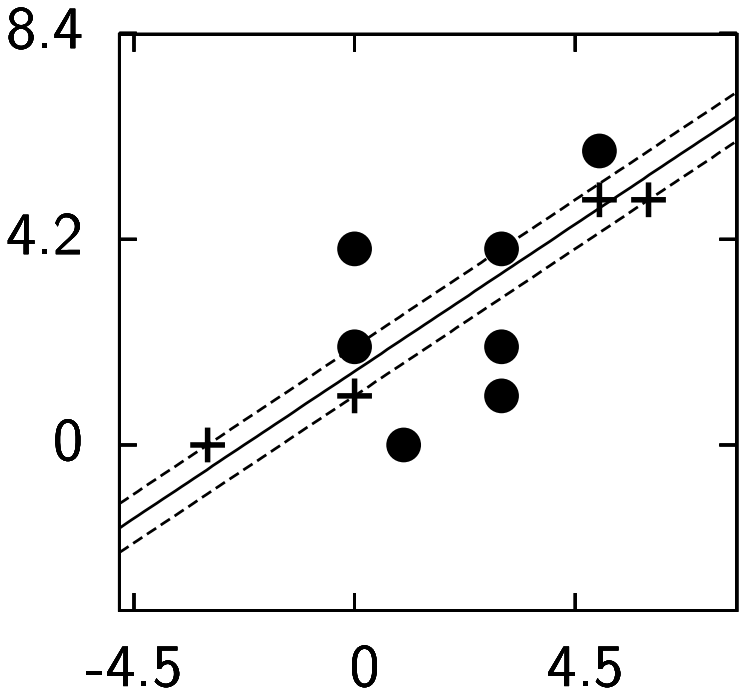

Figure: The idea of ε-SVR. In the figure, there are examples, support vectors (circles), a solution (solid line), and ε boundaries (dashed lines)

The idea of Regression Based on Binary Classification

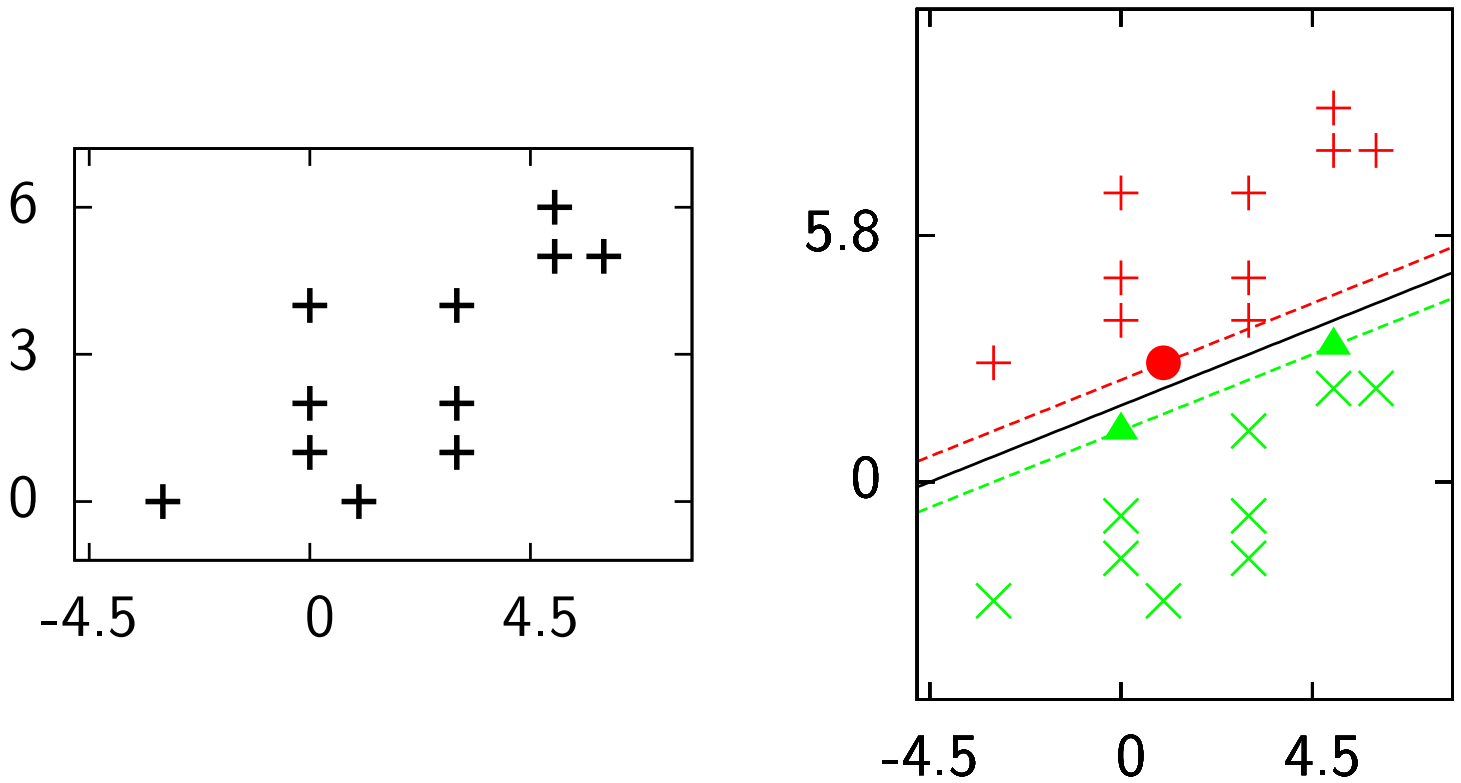

Figure: The idea of the transformation of the problem in δ-SVR for 2d. In the left figure, there are regression example points. In the right figure, there are classification example points after transformation, support vectors (triangles and circles), solution (a solid line), margin lines (dashed lines)

Hybrid Strategy

- divide volume of o for every time slice based on predicted volume participation and information about prices for time slices in rule form

Example

Prices will probably be higher in the second part of T

- the hybrid strategy is to adjust volume participation by including rules about prices
- we propose to use φ-SVC to incorporate rules about prices to prediction of volume participation

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SVC With Margin Weights

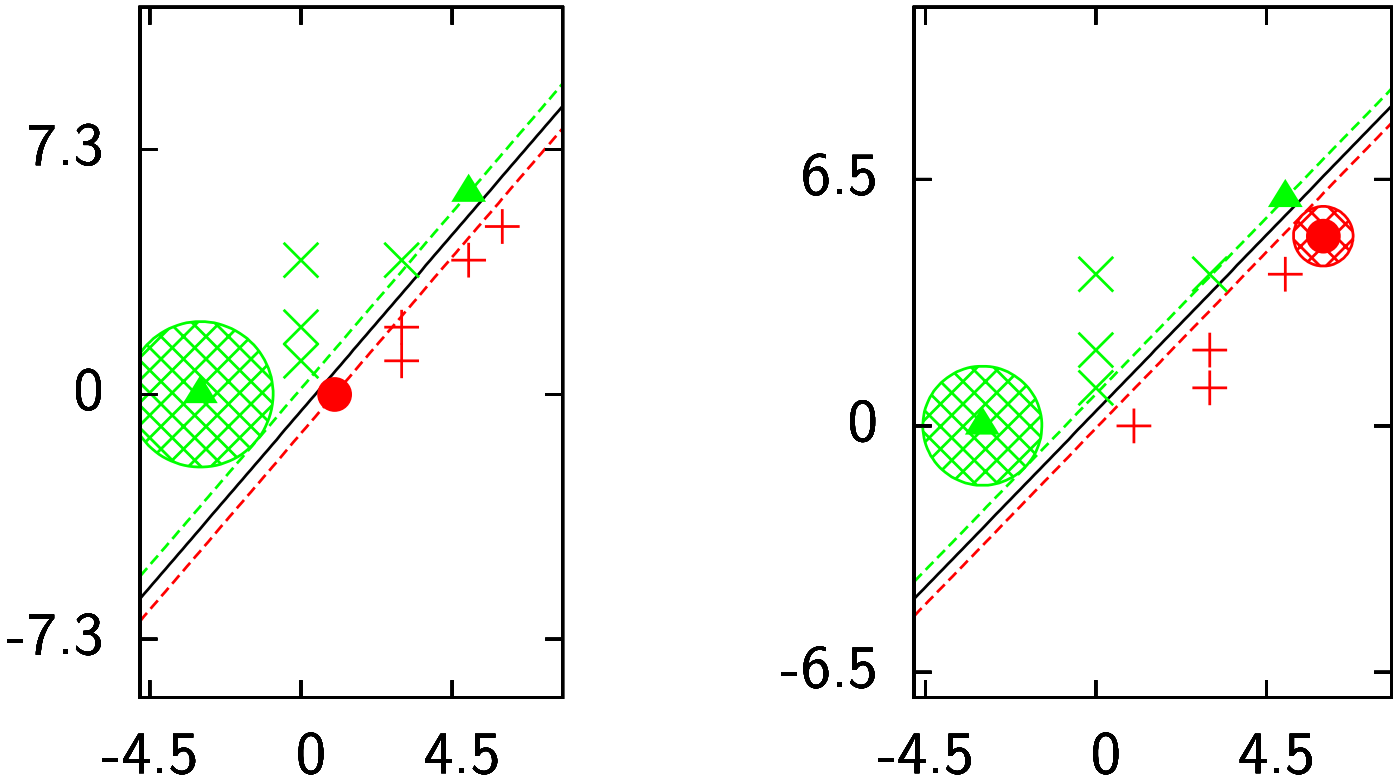

Figure: Interpretation of detractors as dynamic hyperspheres. In the figures, there are example points, solutions (solid lines), support vectors (triangles and circles), tractors (circles filled with grid pattern). In both figures, there is a detractor in (-3, 0) with $\varphi = 5.0$. A radius of a detractor differs in both cases (2.2 and 1.6 respectively)

φ-SVC Formulation

- the simple method of incorporation of price rules is to use some fixed value r of φ_i, e.g. 0.5
- for δ-SVR, e.g. set $\varphi_i = r$ for original examples for the second half of T, set $\varphi_i = r$ for duplicated examples for the first half of T

φ-SVC – Advantages

- φ-SVC can be used with δ-SVR, because δ-SVR transforms the problem into classification problems that can be solved by φ-SVC
- φ-SVC can be used with ε-SVR, because it was shown that ε-SVR formulation is a special case of φ-SVC
- prior knowledge influence on the output function φ-SVC depends on performance of classification

Results

- data tested for NASDAQ-100 securities for about half year period
- T is a one day period
- T is divided to 30 min time slices
- double cross-validation used, inner cross-validation used for finding the best values of parameters, outer cross-validation replaced by shifting data
- training data 2 weeks, validation data 1 week
- while comparing volume participation prediction performance and variance of the final execution error ε-SVR and δ-SVR outperform the simple strategies, with similar results for the strategy based on averages from historical data
- additional information about prices improves the final execution error by about 20%

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Conclusions

- general machine learning methods like SVM can improve the cost of order execution
- by using prior knowledge about prices incorporated to φ-SVC we can create hybrid models for executing orders based on predicting volume participation and information about prices

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