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Decision Support Principles Applied to Model Mixing

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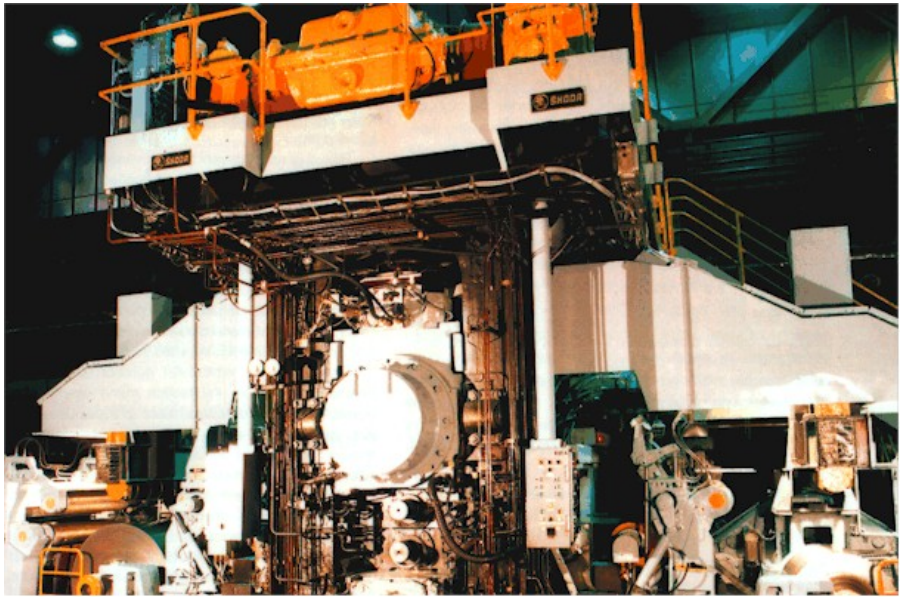
Motivation

- Decision support methods for industrial applications already elaborated
- Complex models may be problematic
- Set of cogitable models available
- Task: continuous selection of process model (or models)
- Possible solution: utilisation of decision support principles

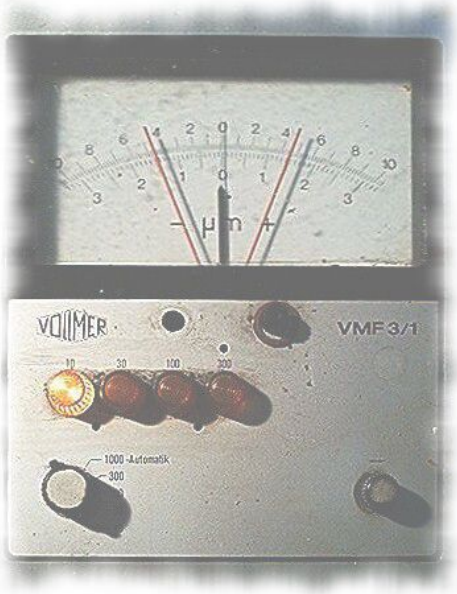
Simple process models

- A process is known to be governed by a physical law ⇒ model
- Known stright relations among variables ⇒ model
- Several physical laws at once, several relations ⇒ a set of models
- Process in question: metall rolling - cold rolling mill



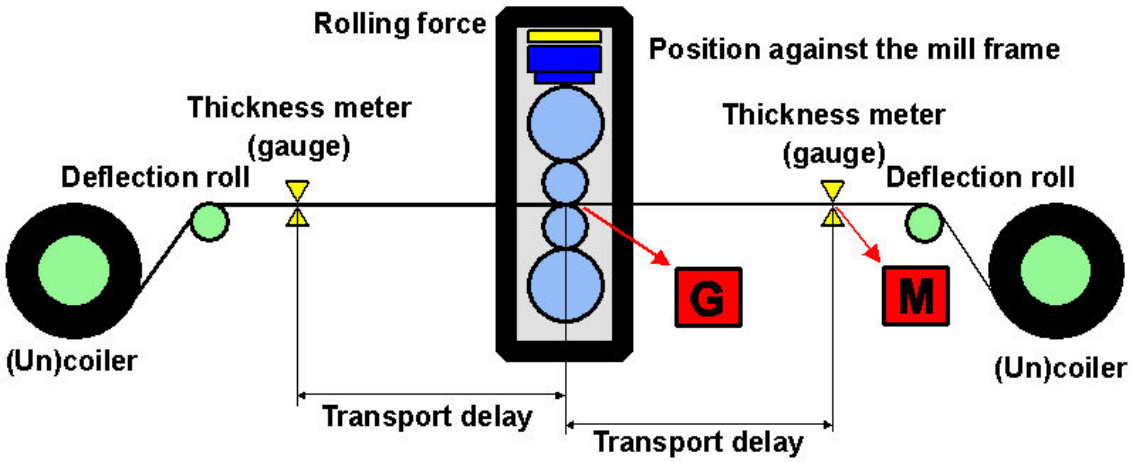
Cold rolling process

- **Rolling mill equipped with a control system including AGC**
- **AGC (thickness control) works excellently under given conditions**
- **Aim 1: to engage or improve the AGC under adverse conditions**
- **Aim 2: AGC or operator support for imperfectly equipped rolling mills**



Configuration

- Task: prediction of outgoing thickness in the rolling gap
- Significant transport delay inherent for rolling mills
- Three or four simple models available
- Each model provides a prediction - none of them is perfect
- Switching or mixing of models ⇒ better prediction ?



Mixing methods

- BA - Bayesian averaging
- MM - Mixture model
- PR - Predictions as regressors
- PM - Predictions as regressors in a mixture

- Different treatment of uncertainty
- Time-delay involved
- Case dependent results expected

BA - Bayesian averaging

- All unknown quantities interpreted as random variables
- Estimation = evaluation of posterior pdf
- Pointer to particular model - random variable as well
- Estimates interpreted as probabilistic weights evolving according to the Bayes rule
- Computational overhead small

MM - Mixture model

- BA does not respect the possibility that for some data configuration some model is not updated adequately
- Overall predictor interpreted as a mixture of predictors
- Probabilistic weights extend the set of unknown parameters
- Algorithm called projection-based Bayesian estimation
- The weights reflect a degree with which the processed data are in harmony with the updated model

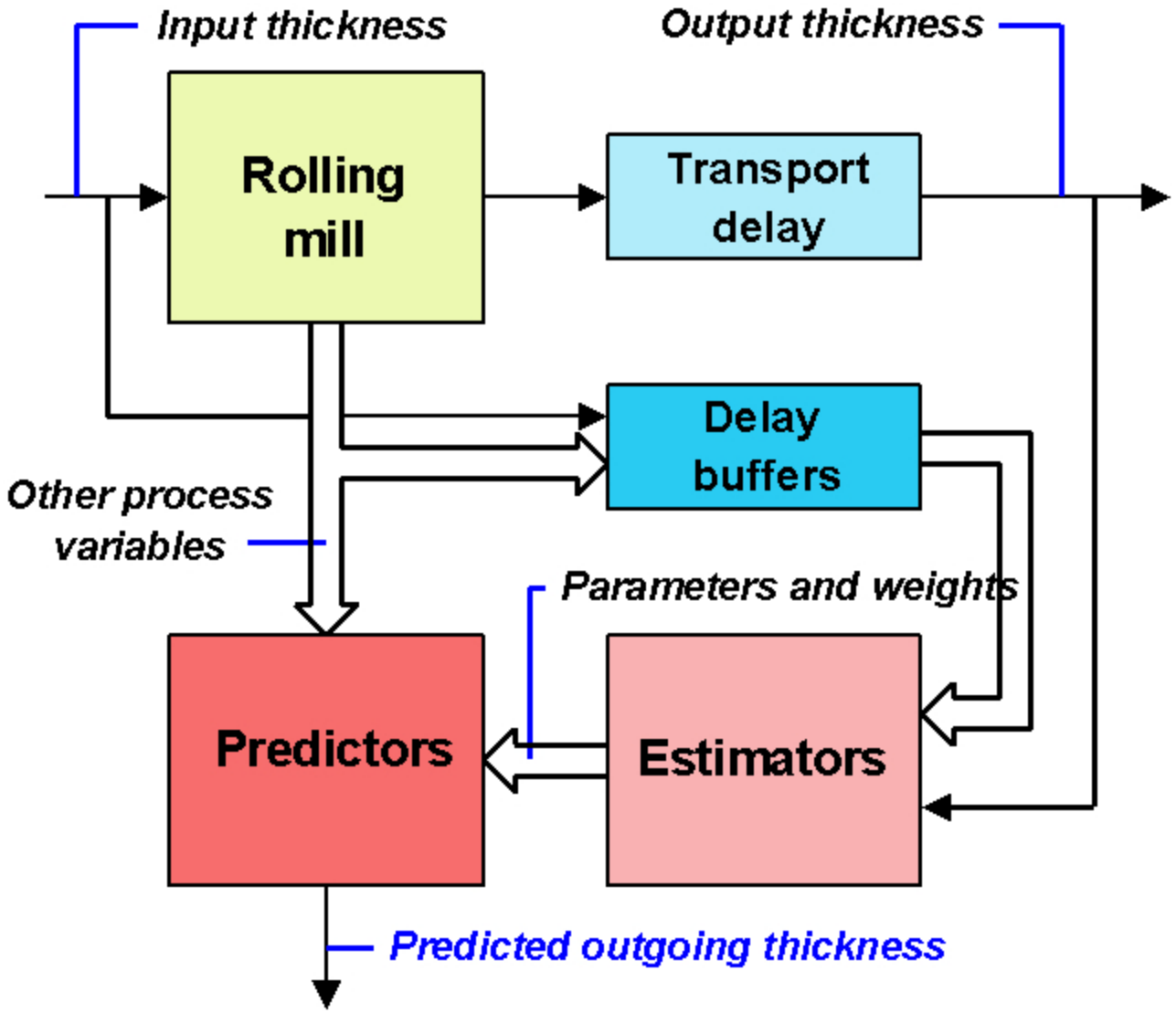
PR - Predictions as regressors

- **BA and MM: overall prediction = convex combination of individual predictions**
- **Problem for cases where the predicted output is outside the "convex hull" of individual model outputs**
- **PR: individual predictions taken as regressors in the overall static model**
- **Estimates $\in$ R, offset estimated as well $\Rightarrow$ overall prediction can be outside the convex hull**
- **Drawback: the same as for BA**

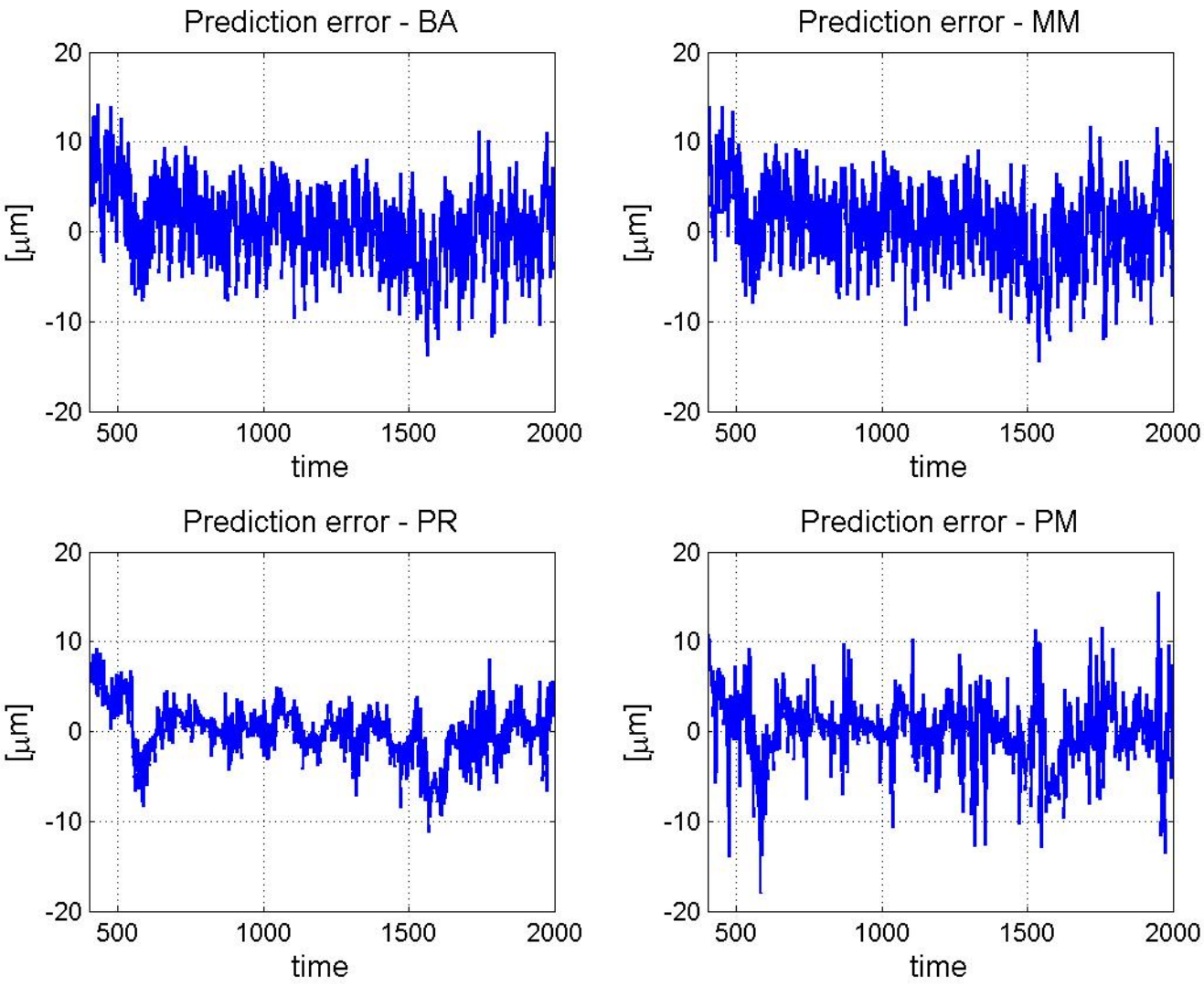
PM - Predictions as regressors in mixture

- Trying to combine advantages of the MM and PR methods
- Overall prediction can be “anywhere”
- Unequal updating of particular models is respected

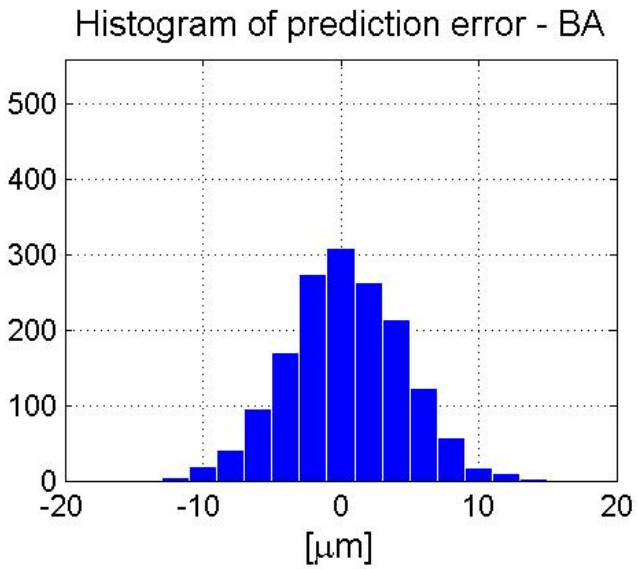
Predictors - schematic diagram

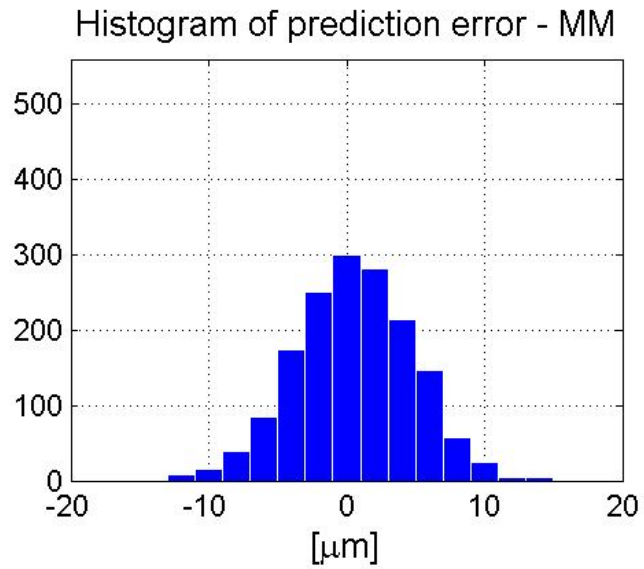


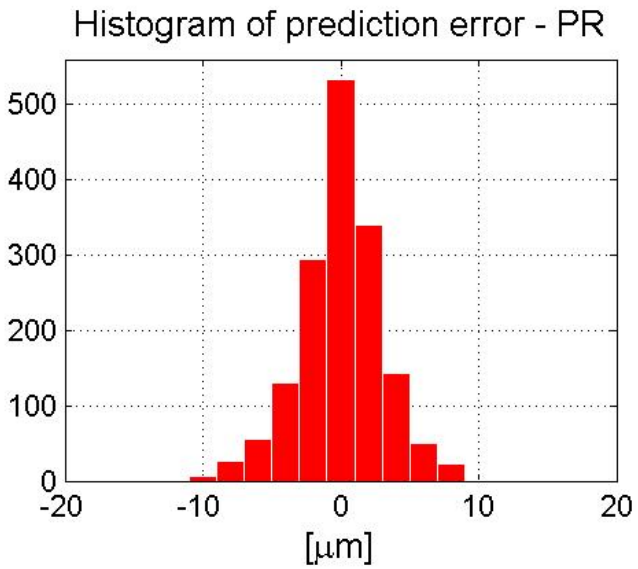
Comparison of results

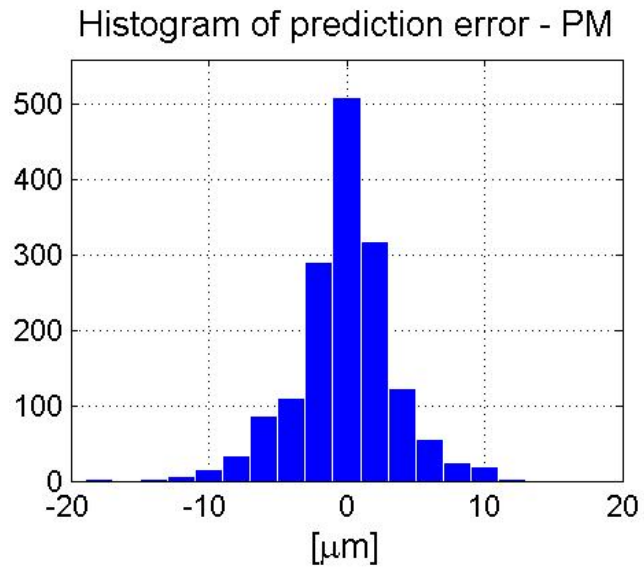


Comparison - histograms









Conclusions

- **Decision support principles were applied for model mixing**
- **Four promising methods introduced**
- **Best results: individual predictions combined into a static regression model (PR)**
- **Results case dependent due to involved approximations**

Publications

Ettler P., Andrýsek J.: *Mixing models to improve gauge prediction for cold rolling mills.* IFAC Symposium MMM'07, Quebec City, Canada

Ettler P., Kárný M., Nedoma P: *Model Mixing for Long-Term Extrapolation.* EUROSIM 2007 Congress, Ljubljana, Slovenia