

# Related Work (1)

## **Regime/Demand Prediction**

- Pauwels et al., 2002/2004
- Kiekintveld et al., 2004
- Wellman et al., 2005

## **Price Prediction**

- Kephart et al., 2000
- Brooks et al., 2002
- Schapire et al., 2002
- Wellman et al., 2003

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## **Opponent Modelling**

- Carmel et al., 1993
- Littman, 1994
- Chajewska et al., 2001

## **Probability of Order**

- Papaioannou et al., 2000
- Benisch et al., 2004
- Ketter et al., 2004
- Pardoe et al., 2004

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# Selected Related Work

Regime/Demand Prediction:

**Pauwels et al., 2002/2004** An analysis on how in economic markets strategic windows of change alternate with long periods of stability.

**Kiekintveld et al., 2004** Define a reference region of operation, and use feedback control actions to suppress deviations from this region.

**Wellman et al., 2005** A method for predicting future demand in TAC-SCM. Their approach depends on knowing the demand formula.

# Example Online Prediction of Current Regime (1)

Day = 1: Best prediction is the prior  $\vec{P}(r_1)$ , and best prior is to use the stationary distribution of the transition matrix:

$$\begin{aligned}\vec{P}^T(r_t) &= \vec{P}^T(r_{t-1})\mathbf{T}(r_t|r_{t-1}) \\ &= \vec{P}^T(r_t)\mathbf{T}^n(r_t|r_{t-1})\end{aligned}$$

$$\Rightarrow \vec{P}^T(r_1) = \vec{P}^T(r_1)\mathbf{T}_{\text{predict}}^n(r_t|r_{t-1}, \Delta t = 1)$$

where  $n$  is a large number, e.g.  $n = 1000$ .

# Example Online Prediction of Current Regime (2)

Day = 2 and  $\Delta t = 1$ :

Step 1: Measurement  $\vec{P}(\text{np}_1|r_1)$

Step 2: Correction:

$$\vec{P}(r_1|\text{np}_1) = \frac{\vec{P}(\text{np}_1|r_1) \vec{P}(r_1)}{\sum_{r_1} \vec{P}(\text{np}_1|r_1) \vec{P}(r_1)}$$

Step 3: Prediction:

$$\vec{P}(r_2|\text{np}_1) = \sum_{r_1} \mathbf{T}_{\text{predict}}(r_2|r_1, \Delta t = 1) \vec{P}(r_1|\text{np}_1)$$

# Example Online Prediction of Current Regime (3)

Day = 3 and  $\Delta t = 2$ :

Step 1: Measurement  $\vec{P}(\text{np}_2|r_2)$

Step 2: Correction:

$$\vec{P}(r_2|\text{np}_2, \text{np}_1) = \frac{\vec{P}(\text{np}_2|r_2) \vec{P}(r_2|\text{np}_1)}{\sum_{r_2} \vec{P}(\text{np}_2|r_2) \vec{P}(r_2|\text{np}_1)}$$

Step 3: Prediction:

$$\begin{aligned} & \vec{P}(r_3|\text{np}_2, \text{np}_1) \\ &= \sum_{r_2} \mathbf{T}_{\text{predict}}(r_3|r_2, \Delta t = 2) \vec{P}(r_2|\text{np}_2, \text{np}_1) \end{aligned}$$

# Online Prediction Current Regime

for  $i = 1$  to  $\Delta t$

Step 1: Measurement:

$$\text{np}_{t+i-1-\Delta t} \Rightarrow \vec{P}(\text{np}_{t+i-1-\Delta t} | r_{t+i-1-\Delta t})$$

Step 2: Correction:

$$\begin{aligned} & \vec{P}(r_{t+i-1-\Delta t} | \text{np}_{t+i-1-\Delta t}, \dots, \text{np}_{t-i}) \\ &= \frac{\vec{P}(\text{np}_{t+i-1-\Delta t} | r_{t+i-1-\Delta t}) \vec{P}(r_{t+i-1-\Delta t} | \text{np}_{t+i-2-\Delta t}, \dots, \text{np}_{t-i})}{\sum_{r_{t+i-1-\Delta t}} \vec{P}(\text{np}_{t+i-1-\Delta t} | r_{t+i-1-\Delta t}) \vec{P}(r_{t+i-1-\Delta t} | \text{np}_{t+i-2-\Delta t}, \dots, \text{np}_{t-i})} \end{aligned}$$

Step 3: Prediction:

$$\begin{aligned} & \vec{P}(r_{t+i-\Delta t} | \text{np}_{t+i-1+\Delta t}, \dots, \text{np}_{t-i}) \\ &= \sum_{r_{t+i-1-\Delta t}} \mathbf{T}_{\text{predict}}(r_{t+i-\Delta t} | r_{t+i-1-\Delta t}, i) \vec{P}(r_{t+i-1-\Delta t} | \text{np}_{t+i-1-\Delta t}, \dots, \text{np}_{t-i}) \end{aligned}$$

end

# Example of Regime Prediction

Game number: 1130tac3

delta\_t = 15

Off-line: 80 0.9913 2 0.1317 0.5775 0.2908

Online Simple: 80 0.9108 2 0.2332 0.6213 0.1455

Online Markov: 80 0.9108 2 0.0455 0.8200 0.1345

Online s-Mar.: 80 0.9108 2 0.0322 0.8403 0.1275

Markov Pred.: 95 n/a 2 0.2983 0.5136 0.1881

s-Mar. Pred.: 95 n/a 2 0.1925 0.5613 0.2462

Off-line: 95 0.9659 2 0.1609 0.6099 0.2291

Online Simple: 95 0.9222 2 0.2166 0.6256 0.1578

Online Markov: 95 0.9222 2 0.0449 0.8248 0.1303

Online s-Mar.: 95 0.9222 2 0.0401 0.8160 0.1439

RMSE Markov = 0.0997

RMSE semi-Markov = 0.0349

