

On-line Detection of Rule Violations in Table Soccer

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Motivation

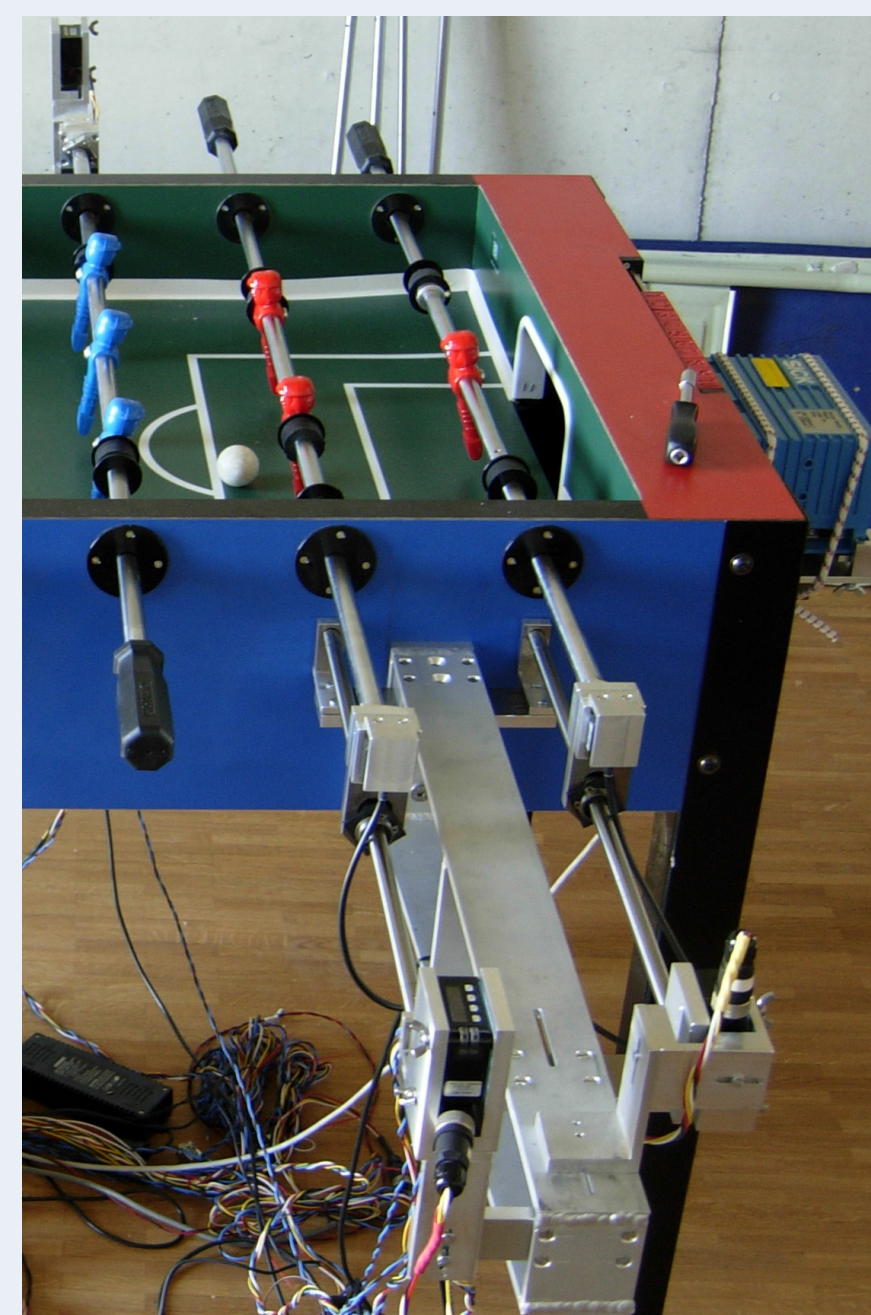
- Tournament-level games in table soccer have to follow a strict ruleset.
- Fast actions are hard to observe, especially when involved in the game.
- An autonomous referee can reliably observe the game state with sensors.
- Most rules depend on the detection of a kick. We concentrate on this key element.
- Detected violation:

Rods may not be rotated by more than 360 degrees before or after ball contact.

1: Observing games in realtime

• KiRe – Kicker Recorder

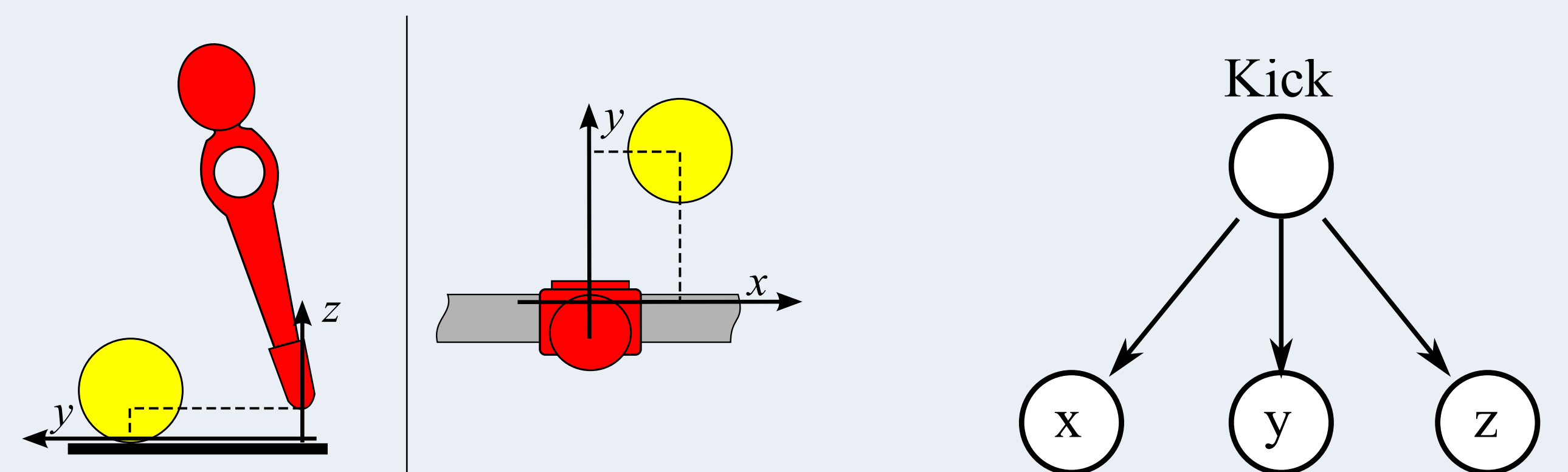
- **Ball position:** Laser Scanners under playing figures
- **Rod position:** Laser Distance Sensors
- **Rod angle:** Contactless magnetic rotary encoders
- Noisy sensor observations



- High speed of the game requires high frequency of sensor data (250 Hz)
- Real-time interpretation on different computer, distributed over network

2: Kick classification

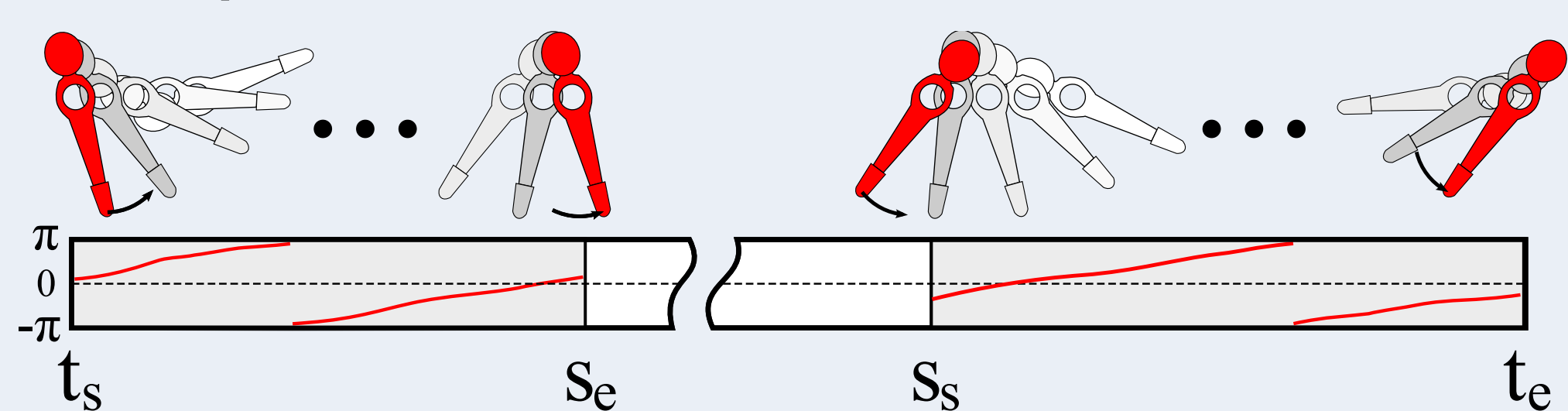
- Naive Bayes: fast and efficient implementation, sufficient classification performance
- Input variables: coordinates of ball relative to closest playing figure



- Figure is classified as kicking if:
$$P(K|x, y, z) = \alpha P(x|K)P(y|K)P(z|K) > \theta$$
- $P(x|K)$, $P(y|K)$, $P(z|K)$ as Gaussian distributions, learned with supervised learning

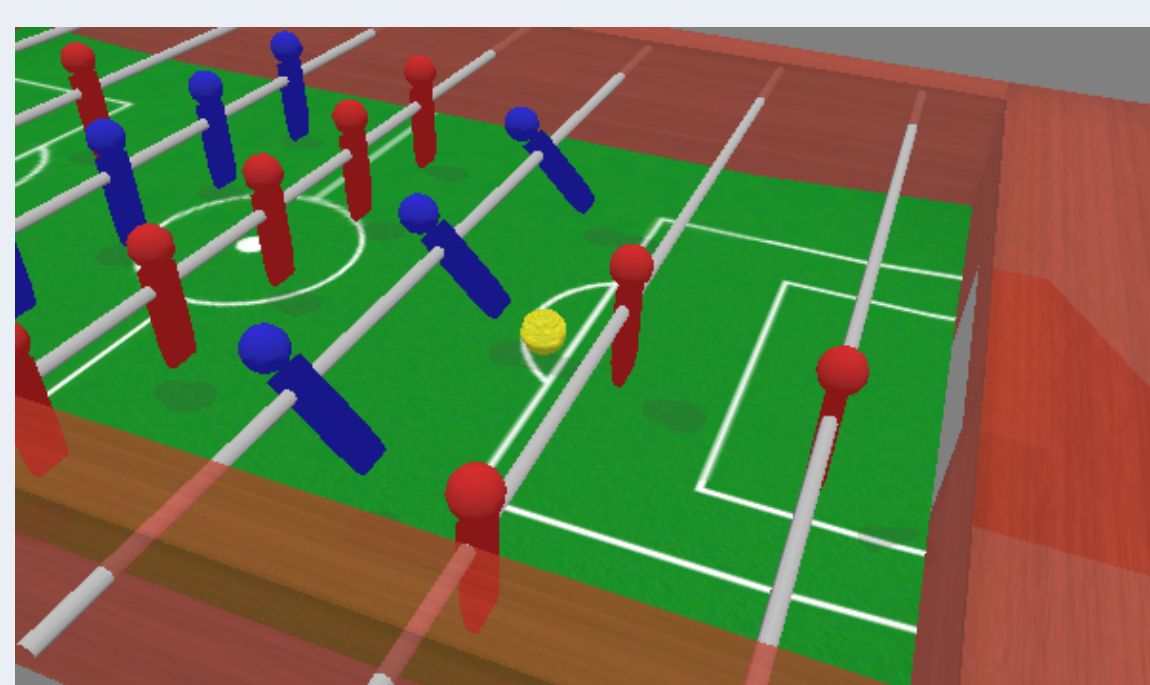
3: Violation Detection

- Rod angle data is constantly monitored and segmented into coherent spin movements ($t_s - t_e$)
- If there is a spin of more than 360°:



alert a violation if there was a kick on that rod after s_e or before s_s

- Players are alerted of violations by a sound, followed by a slow-motion replay



4: Results and future work

• On-line detection in real games

- 11 test subjects played 9 games for about 1:45h
- Rule violations were silently logged, players evaluated their own performance
- Results: 19 illegal kicks.

Human detection rate 10.52% (2 violations)

System detection rate: 89.47% (17 violations)

• Future work

- Improved robustness on kick classifier
- More rules (passes)
- Transfer rule detection to table soccer robot *Star-Kick*