Duration Models for Human Activity Prediction in Industry-Like Tasks

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Can we use temporal information from human activity sequences to predict future activities?

Context

HMM are already efficient for Activity Recognition [1] but can they predict future activities before they could be observed ?
Hidden Semi Markov Models (HSMM) [2]:

- Encode explicitly temporal information
- Describe non-homogeneous Hidden Markov Processes

➡ Can we improve recognition and predict future activities ?

Methodology

Model Description

The state:

- Activity at time t: $A_t = i$ with $i \in \mathcal{S}$
- Sojourn time E_t in activity $A = i$ at time t
- O_t is the observation generated at t.

The model is defined by

- Transition process $P(A_{t+1}, E_{t+1}|A_t, E_t)$
- Observation model $P(O_t|A_t, E_t)$

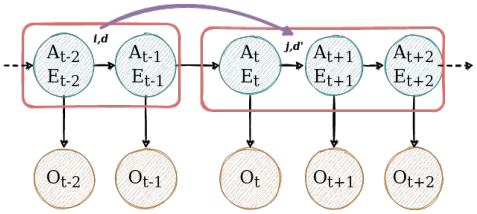

Figure 1: Graphical model of a HSMM

Models of interests

- **Explicit Duration HMM**
  - $P(A_{t+1}, E_{t+1}|A_t, E_t) = \frac{\sum_{d=\tau} P(d|A=i)}{\sum_{d=\tau-1} P(d|A=i)}$ if $A_{t+1} = A_t$ and $E_{t+1} = E_t + 1 = \tau$
  - $P(A_{t+1}, E_{t+1}|A_t, E_t) = P(A_{t+1}|A_t)\left(1 - \frac{\sum_{d=\tau} P(d|A=i)}{\sum_{d=\tau-1} P(d|A=i)}\right)$ if $A_{t+1} \neq A_t$
- **Variable Transition HMM**
  - $P(A_{t+1}, E_{t+1}|A_t, E_t) = P(A_{t+1}|A_t, E_t)$
  - $E_{t+1} = E_t + 1$ if $A_{t+1} = A_t$ else $E_{t+1} = 1$

Objectif: Predicting the future at horizon h: $P(A_{t+h}|O_{1:t})$

Evaluation

Supervised learning of model's parameters

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Use of labeled dataset of industry-like activities

Activity Transition distributions

Activity Duration distributions

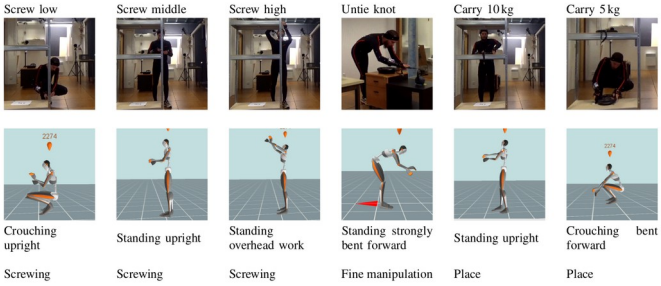

Figure 2: The 6 tasks of the dataset with associated posture
and action following the dataset taxonomy [3]

Results

Figure 3: The accuracy of each model to detect successfully predict an activity transition at horizon 5, 10 and 20 steps ahead. We see that for the model that does not incorporate knowledge (HMM) on activity duration performs is less accurate to detect transition of activity

Conclusion

Including temporal component of activities:

- We predict Activity Transition better
- We can infer future activity

Usable in HRC scenarios without the need large datasets. However, it is preliminary works on duration models and we are working to improve its performance.

References

[1] MALAISÉ, Adrien, MAURICE, Pauline, COLAS, Francis, et al. "Activity recognition with multiple wearable sensors for industrial applications", *Eleventh International Conference on Advances in Computer-Human Interactions*. 2018.
[2] YU, Shun-Zheng. "Hidden semi-Markov models". *Artificial intelligence*, 2010, vol. 174, no 2, p. 215-243.
[3] MAURICE, Pauline, MALAISÉ, Adrien, AMIOT, Clélie, et al. Human movement and ergonomics: "An industry-oriented dataset for collaborative robotics". *The International Journal of Robotics Research*, 2019, vol. 38, no 14, p. 1529-1537.

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