Self-taught learning for activity spotting in on-body motion sensor data

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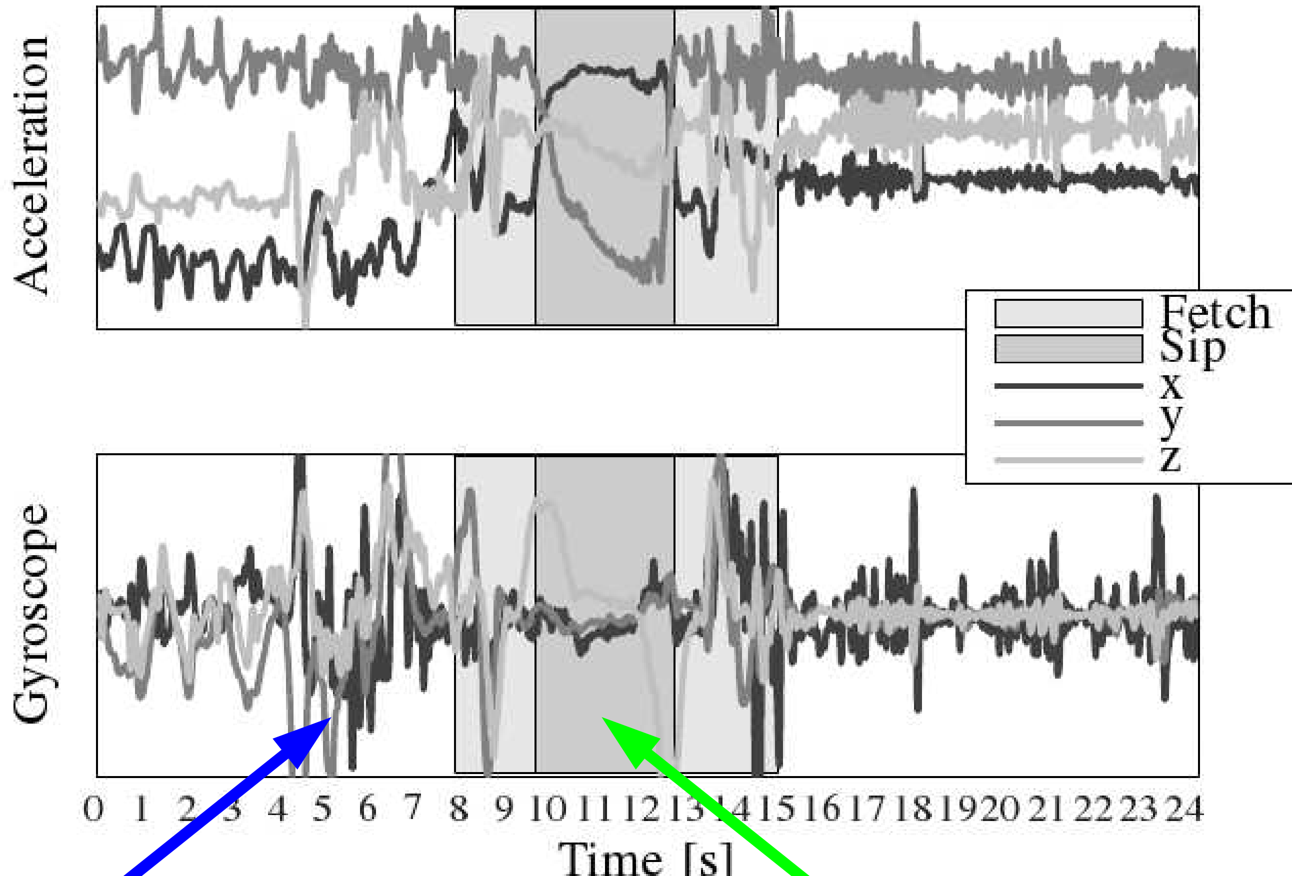
Interpreting daily routines

Picking relevant events:

What is activity spotting?

Example: drinking motion spotting

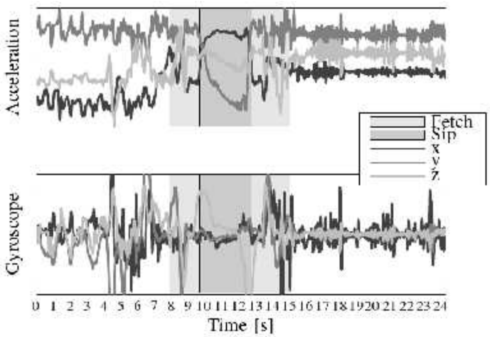


Unsupervised

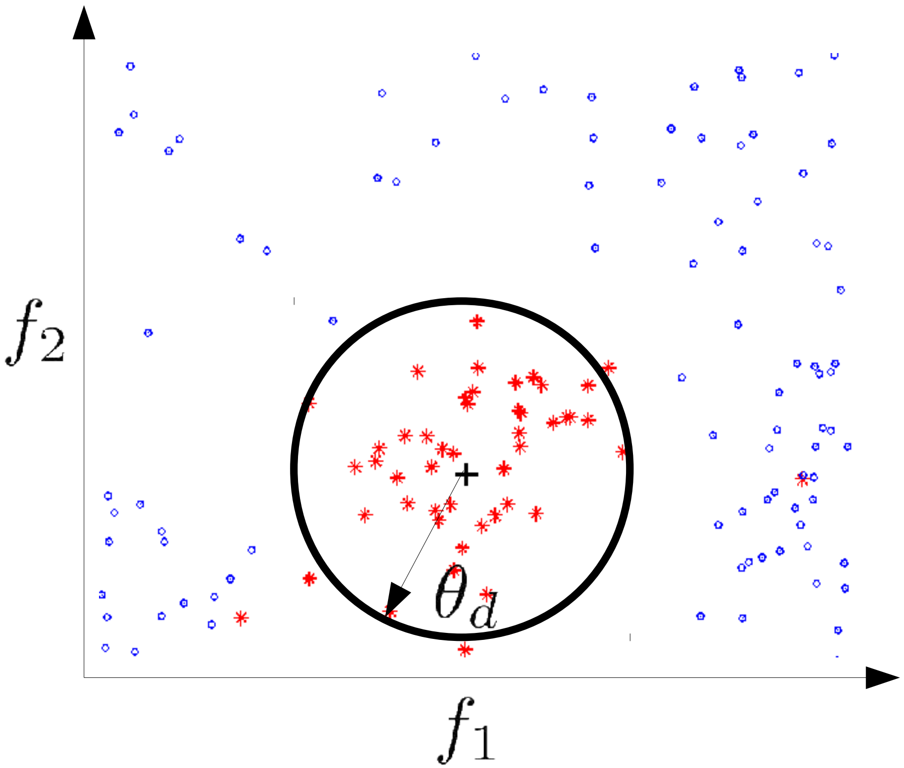
Supervised

Amft et al., PerHealth 2010

How does self-taught learning help?



How does activity spotting work? (Example)



$$\mathcal{X}_{Train} = \{\underline{\mathbf{f}^{+}_{Train}}, \underline{\mathbf{f}^{-}_{Train}}\}$$

Centroid Model:

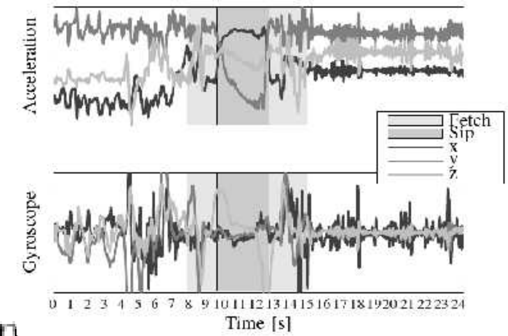
$$d(\mathbf{f}) = \sqrt{\sum_{i=1}^{|\mathbf{f}^{+}|} \left(\frac{f_i^{+} - \bar{f}_i^{+}}{s_i} \right)^2}$$

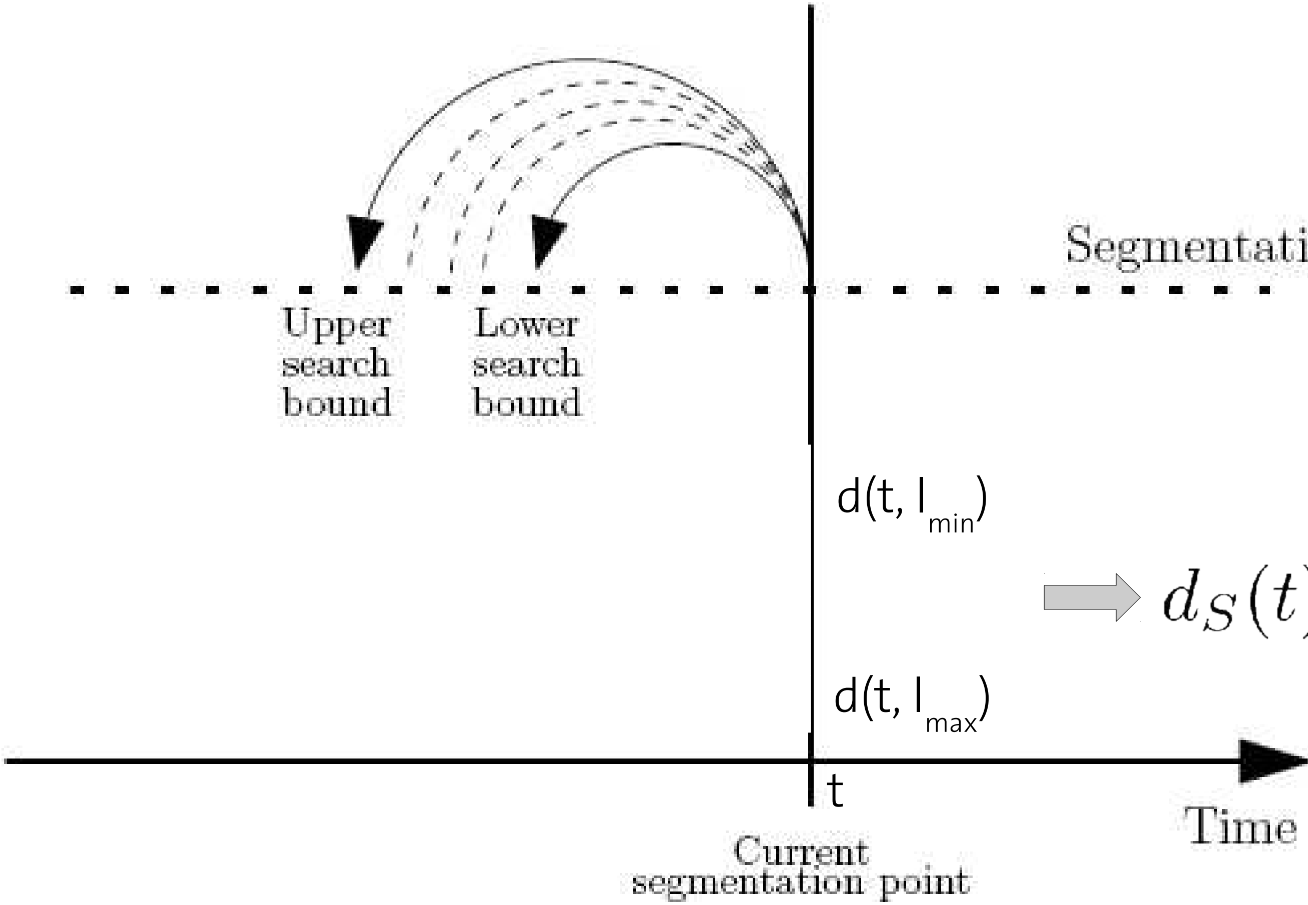
$$h_{FSS} = \begin{cases} true, & d_S \leq \theta_d \\ false, & otherwise \end{cases}, [p]$$

$$\theta_{d,Train} = \underset{\theta_d}{\text{argmin}}\ \varepsilon_{emp}(h_{FSS}, \theta_d, \mathcal{X}_{Train})$$

Amft, SUTC 2010

The Feature Similarity Search (FSS) method



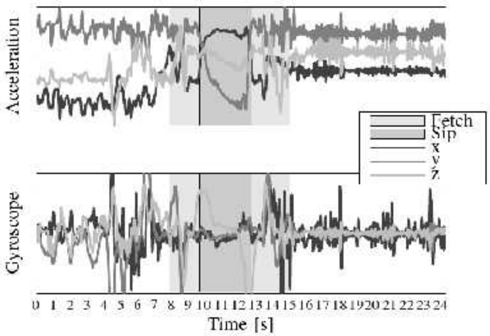


$$d_S(t) = \min_l d(t, l)$$

Amft & Tröster, Artif Intell Med, 2008, 42(2)

Junker et al., Pattern Recognition, 2008 41(6)

Self-taught learning



Approach: learn from background

1. Learn representation $\{b_j, a_j^{(i)}\}$ from unlabelled data $x_u^{(i)}$
2. Apply $\{b_j, a_j^{(i)}\}$ using labels $x_l^{(i)}$ to derive features $\hat{a}$
3. Use supervised spotting learner to obtain model $h : \hat{a}(x_l^{(i)}) \rightarrow e_{C,T}$

1. Optimisation problem:

$$\min_{\{b_j\},\{a^{(i)}\}} \sum_{i=1}^{k} ||x_u^{(i)} - \sum_{j=1}^{s} b_j a_j^{(i)}||_2^2 + \beta \sum_{i=1}^{m} \sum_{j=1}^{s} \phi(a_j^{(i)})$$

$$\text{s.t.} \quad ||b_j||^2 \leq c, \ \forall j = 1, \ldots, s$$

2. Higher-level features:

$$\hat{a}(x_l^{(i)}) = \underset{a^{(i)}}{\operatorname{argmin}} ||x_l^{(i)} - \sum_{j=1}^{s} b_j a_j^{(i))} ||_2^2 + \gamma \sum_{j=1}^{s} ||a^{(i)}||_1$$

Adapted from Raina et al., ICML 2007 & Lee et al., NIPS 2006

Evaluation dataset used

Office


Gaming


Eating

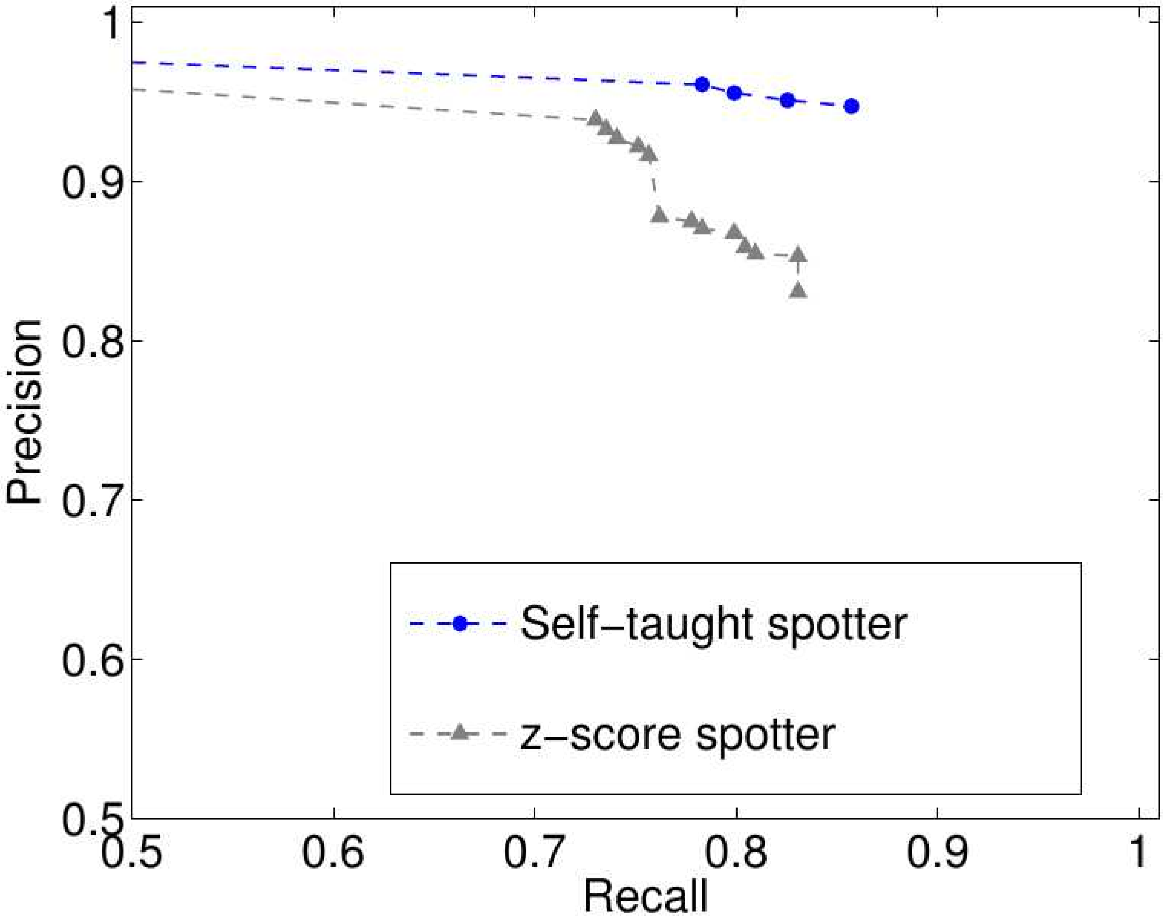

Leisure

Dataset properties:

- wrist inertial sensor
- six students
- 5.84 h data
- 655 annotated sips
- (1-g) > 90%

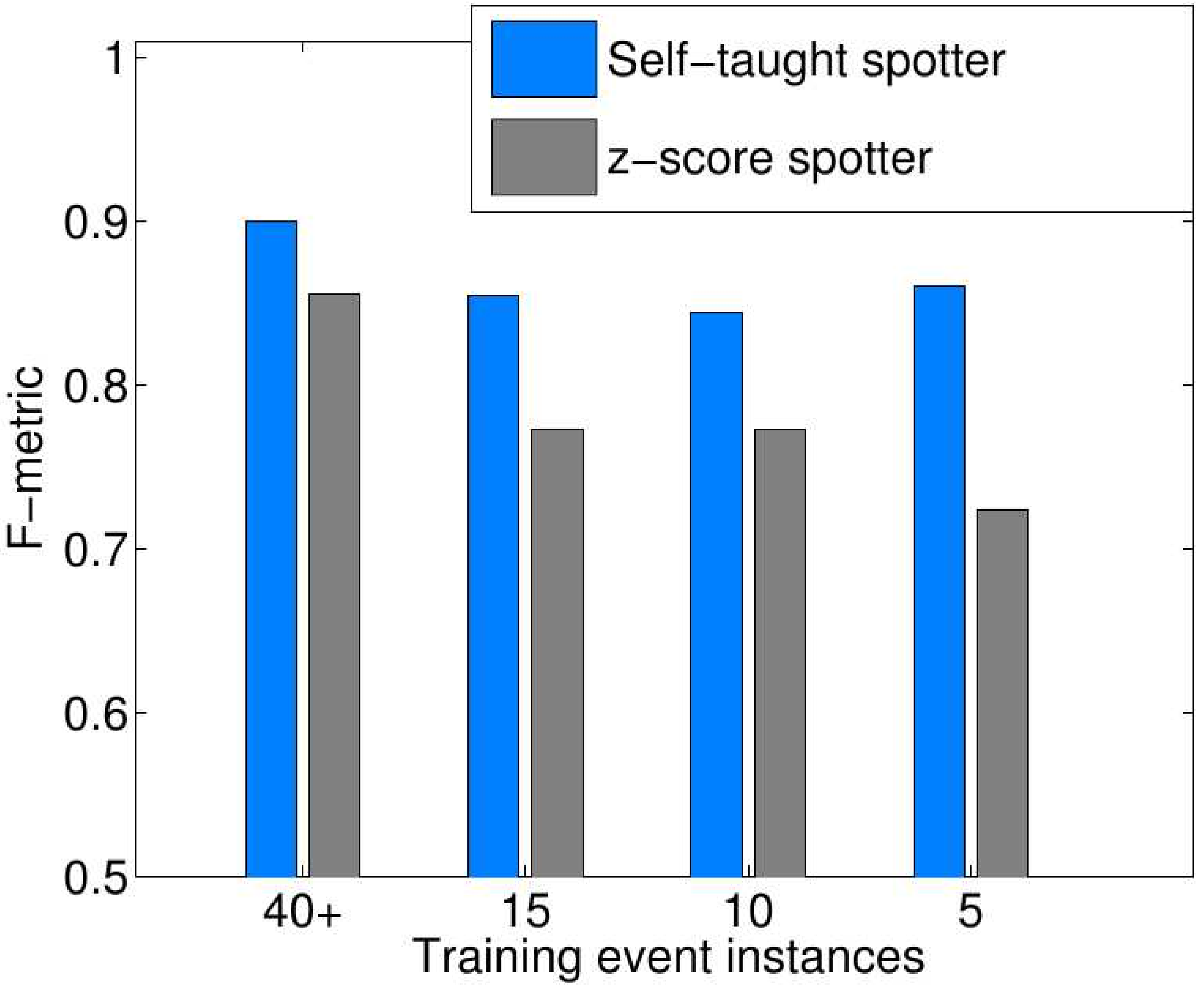
Amft et al., PerHealth 2010

Performance comparison*



* FSS decision threshold sweep.

Constraint training performances



Main messages:

- Properties of self-taught approach fit well with activity spotting problem.
- Self-taught spotting yields better performance in motion/gesture spotting.
- Self-taught spotter showed improved robustness when limited training examples are available.

Acknowledgements

David Bannach, Gerald Pirkl, Matthias Kreil, Paul Lukowicz,
Univ Passau/Germany

ACTLab, TU Eindhoven

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