Demo: Automated Micro-Activity Annotations for Human Activity Recognition with Inertial Sensing

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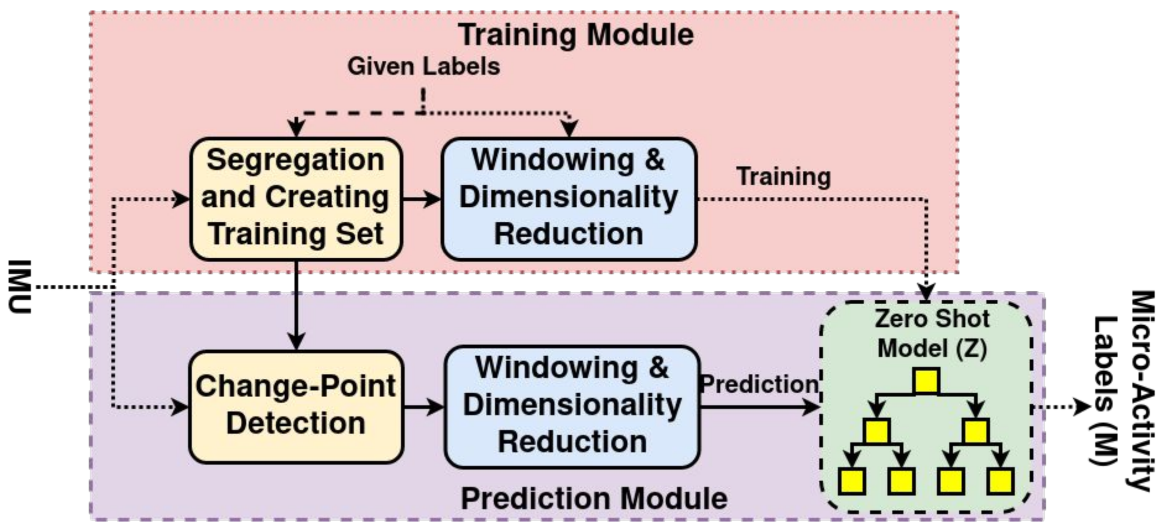
Motivation and Broad Idea



1. Automating the complicated tasks of getting annotations for micro-activities
2. **Challenges:** Number and characteristics of the micro-activities may not be known apriori
3. **Primary Idea:** Using the short-duration macro-activity labels along with zero-shot learning
4. Experiments done on Kitchen dataset [1] containing complex activities of daily living

Zero-Shot Learning and Verb Attribute Embeddings

Transitivity			Aspect	Motion	Time	Social	Bodyparts					Effect on Arguments											
							Arms	Head	Legs	Torso	Other												
1	1	1	3	3	1	0	1	0	0	0	0	0	1	0	0	0	1	1	0	0	1	1	0

Sample verb-attributes [2] for the activity verb "*spray*" from the Kitchen dataset

Training with Short-Duration Macro-Activities

Algorithm 1 Training the Zero-Shot Model

Input: Training Set $\mathbb{V} = \{(u, a) : u \in \mathcal{I}, a \in \mathcal{A}\}$, where $\mathcal{I}$ is the accelerometer data and $\mathcal{A}$ is the set of short-duration macro-activity labels.
Output Trained zero-shot model $\mathbb{Z}$

1: $(\mathbb{S}, \mathcal{A})$ = *red_dimen_labelwise* $(\mathbb{V}, d)$ {We fix $d = 2$. Here, $\mathbb{S}$, which is the transformed accelerometer data with dimensions reduced to d.}
2: $\mathbb{Z} = []$
3: **for** $i = 1$ to $\mathbb{N}$ **do**
4: $\quad\mathbb{Z}[i]$ = train_model($\mathcal{R}_i$, $\mathbb{S}$, verb_attribute($\mathcal{A}$)[:,i])
5: **end for**
6: return $\mathbb{Z}$

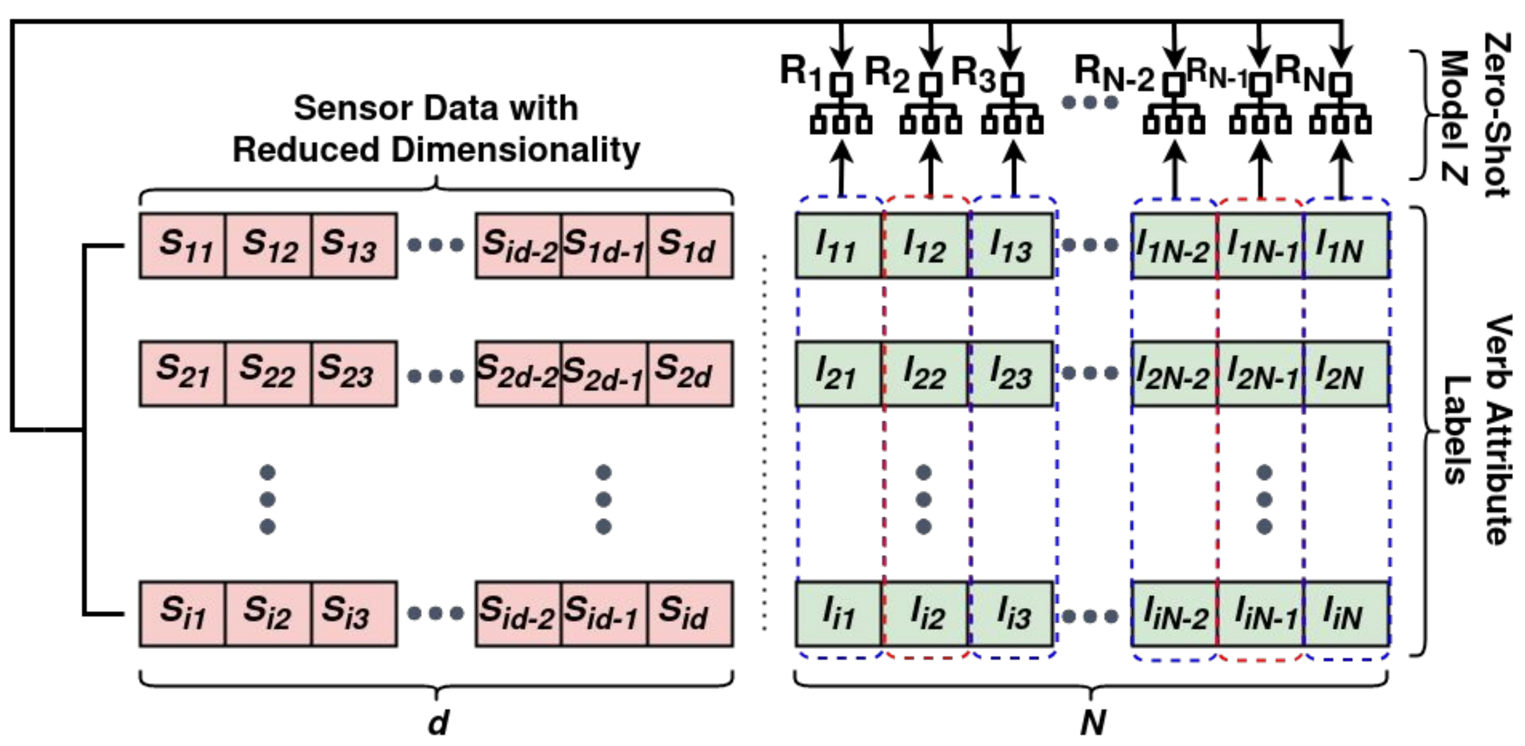


Fig. Zero-shot model as an array of classifiers

Finding Unknown Micro-Activities

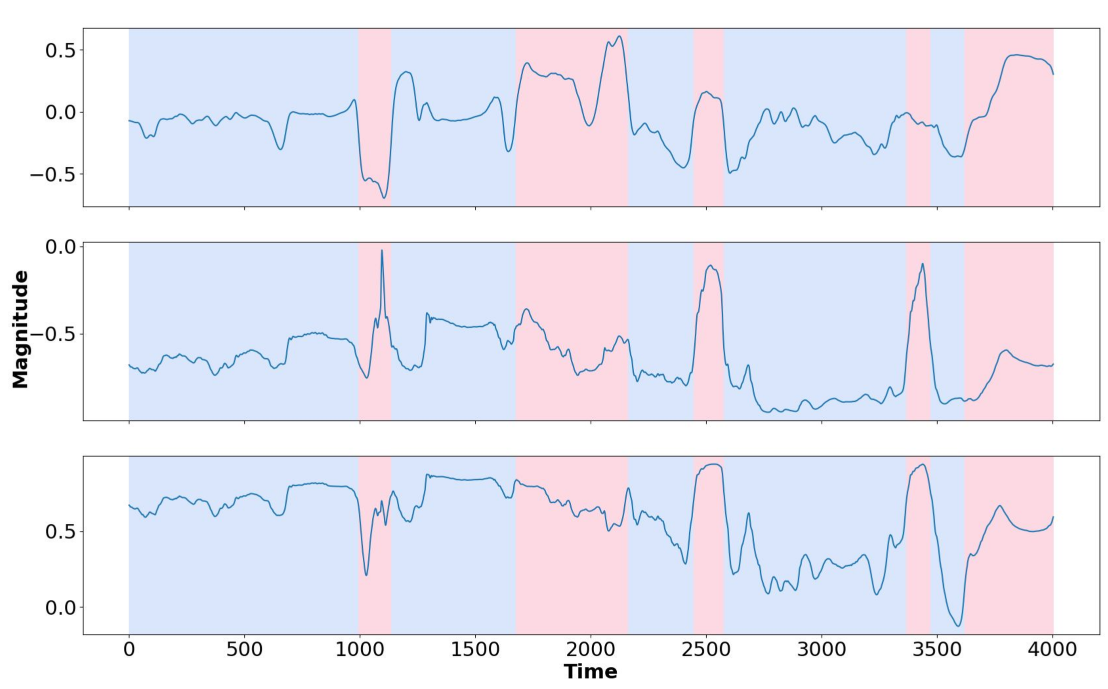


Fig. Change-points detected with penalty 50

1. Unsupervised change-point detection can help locate the activity boundaries
2. Each activity window can potentially represent one micro-activity
3. Use window-based change-point detection [3] with window-size = 100 and RBF kernel

Generation of Micro-Activity Annotations

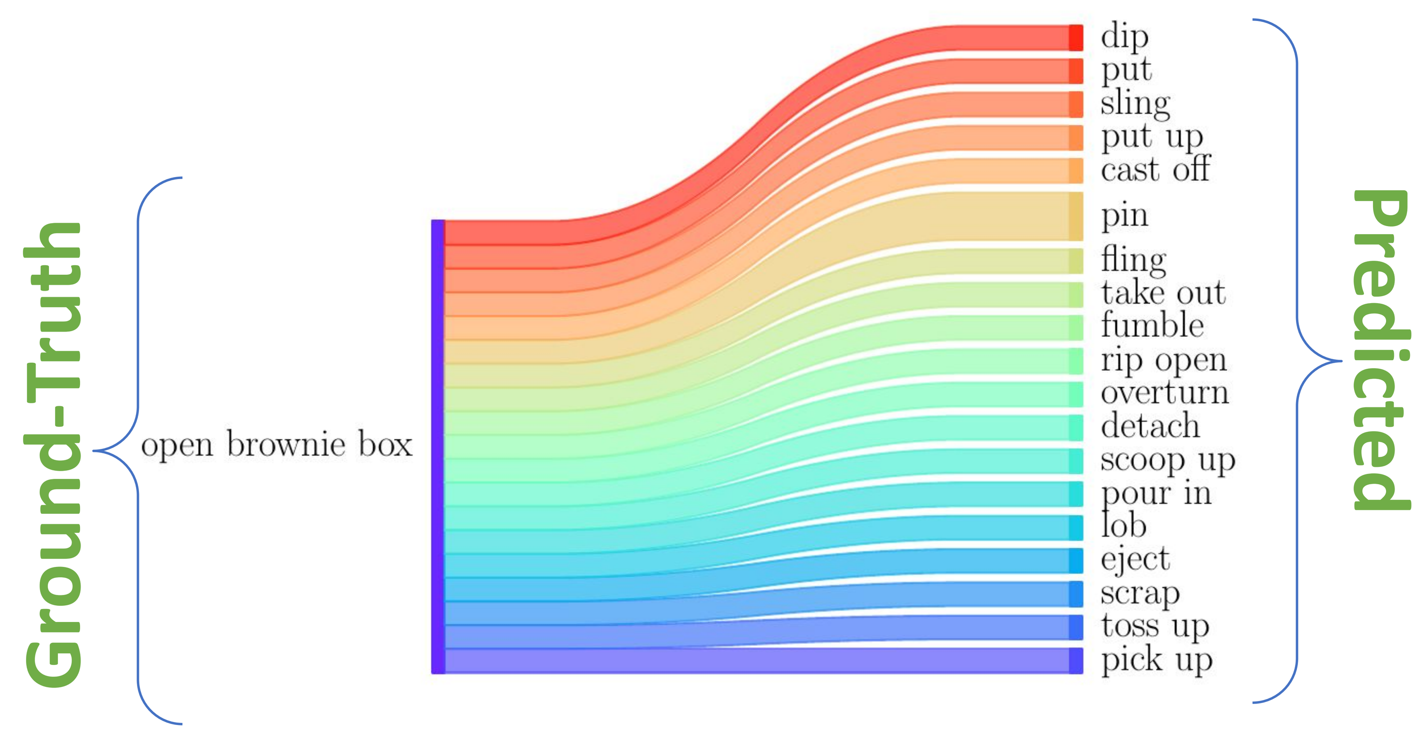
Algorithm 2 Predicting Micro-Activities

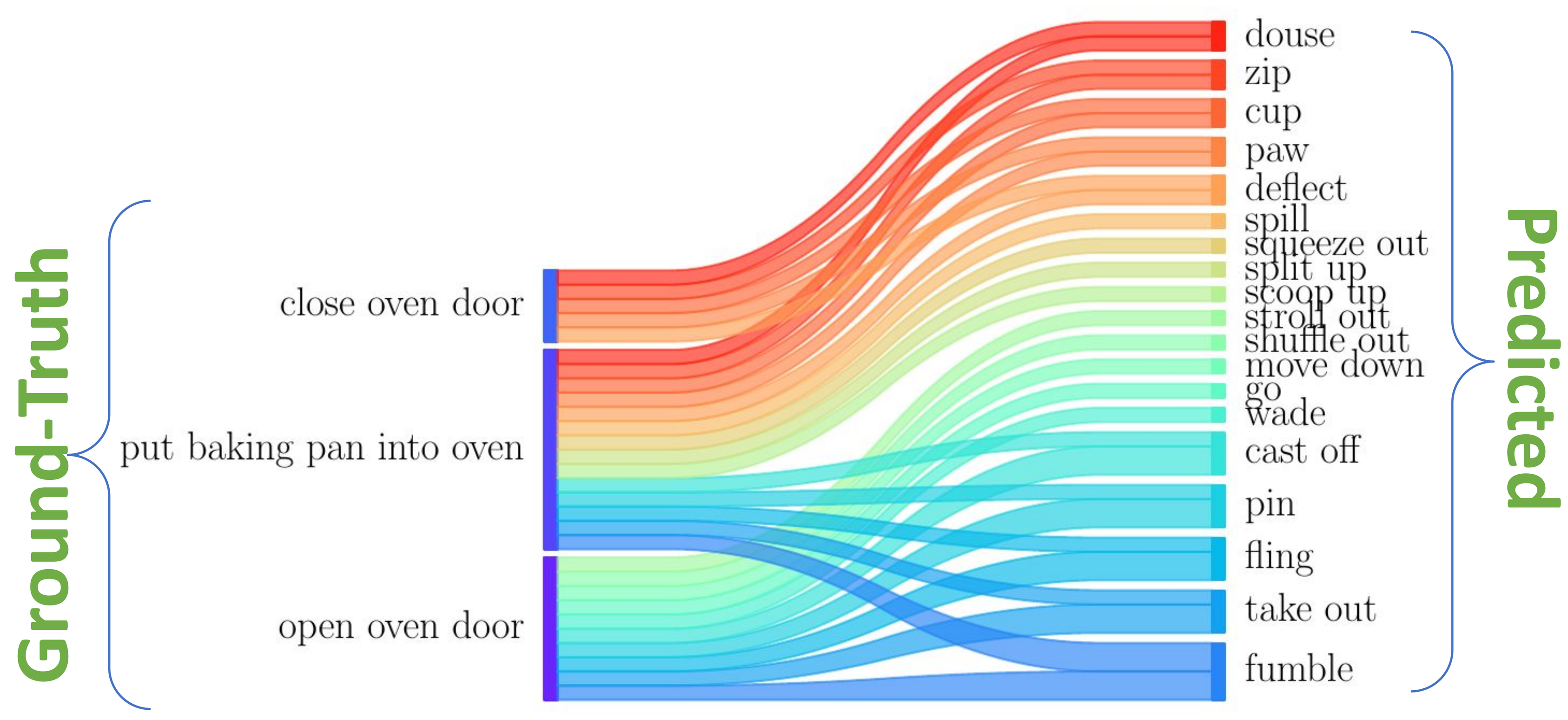
Input Accelerometer data $\mathcal{I}^t_{t+\tau}$ for activities where $\tau \geq 10$s and the trained zero-shot model $\mathbb{Z}$.
Output Predicted micro-activities $\mathbb{M}^t_{t+\tau}$, where $\mathbb{M}^t_{t+\tau} = \{m_1, m_2, \ldots, m_n\}$, where n is the total number of micro-activities performed by the subject in the time duration $[t, t+\tau]$.

1: $\mathbb{W}^t_{t+\tau}$ = *change_point*$(\mathcal{I}^t_{t+\tau})$ {Here, $\mathbb{W}^t_{t+\tau}$ is the set of change-point windows.}
2: $\mathbb{M}^t_{t+\tau} = \{\}$
3: **for** each change window ω in $\mathbb{W}^t_{t+\tau}$ **do**
4: $\quad J_\omega$ = average accelerometer data fro the window ω
5: $\quad \mathcal{J}_\omega$ = *red_dimen* (J_ω, d) {We fix $d = 2$.}
6: $\quad m_\omega$ = *predict_micro_activities* $(\mathbb{Z}, \mathcal{J}_\omega)$ {Here, m_ω is the micro-activity predicted for the change-window ω.}
7: $\quad \mathbb{M}^t_{t+\tau} = \mathbb{M}^t_{t+\tau} \cup \{m_\omega\}$
8: **end for**
9: return $\mathbb{M}^t_{t+\tau}$

1. Accelerometer across change-point windows is used as an input to the zero-shot model
2. Output is a set of micro-activities in the form of attribute embeddings
3. Micro-activities defined by observing the closest known verbs in the embedding space
4. **Limitations:** Unnecessary verbs may appear due to hubness

Demonstration of Labeling Performance





References

[1] E. H. Spriggs, F. De La Torre, and M. Hebert, "Temporal segmentation and activity classification from first-person sensing," in IEEE CVPR Workshops. IEEE, 2009, pp. 17–24.
[2] R. Zellers and Y. Choi, "Zero-shot activity recognition with verb attribute induction," in EMNLP, 2017.
[3] C. Truong, L. Oudre, and N. Vayatis, "Selective review of offline change point detection methods," Signal Processing, 2020.

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