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Improving Human Activity Recognition with Data Sources Integration

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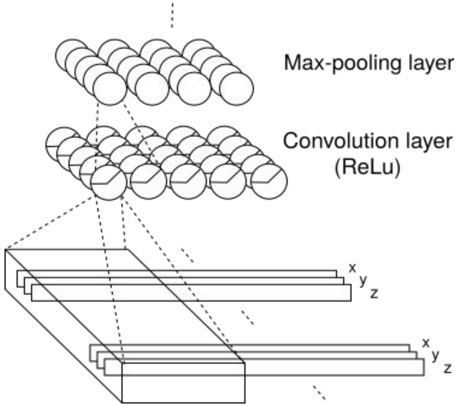
Context & Motivation

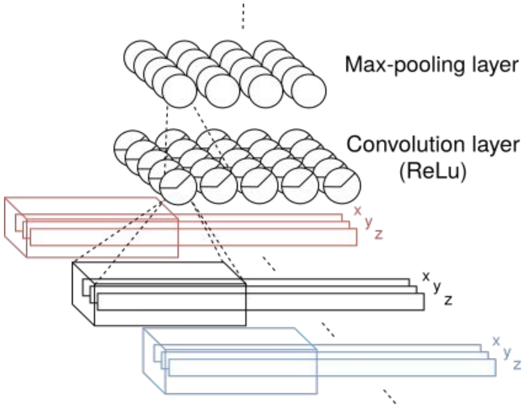
- How does the data generation step impact learning processes?
- How to deal with sensors deployments, Internet of Things environments, etc.?
- How to incorporate sensors deployment topology to improve data sources integration?
- How to come-up with similar insights as in [Foerster & al., Mantyjarvi & al., Reddy & al.] (without human expertise and heavy experimentation)?

F Foerster, M Smeja, J Fahrenberg - Computers in Human Behavior, 1999
Mantyjarvi, Jani, & al. *IEEE International Conference on Systems, Man and Cybernetics.* Vol. 2. IEEE, 2001
Reddy, S., Mun, M., Burke, J., Estrin, D., Hansen, M., Srivastava, M. ACM Transactions on Sensor Networks (TOSN) 6(2), 13, 2010

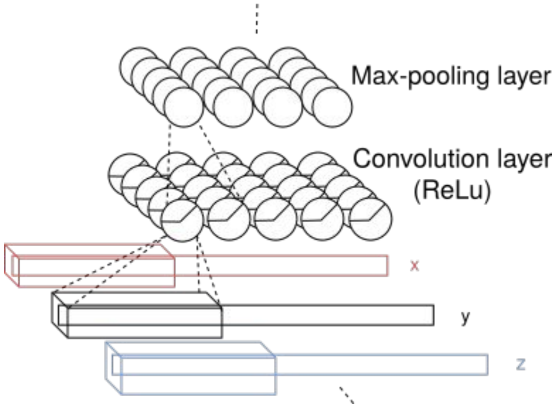
Features learning and fusion strategies



Modalities Grouped



Split Modalities

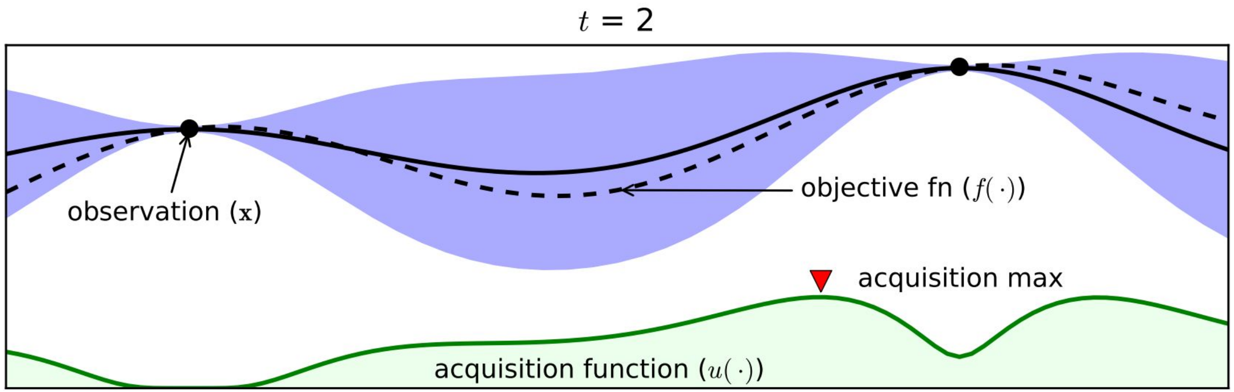


Split Channels

- Convolutional modes + hyperparameters instantiations define a neural architectures space;
- But, Exploration of the whole neural architectures space is unfeasible.

Optimal Exploration of the Neural Architectures Space

- Bayesian optimization based on Gaussian process surrogate model and expected improvement;
- Good trade-off between exploration and exploitation;



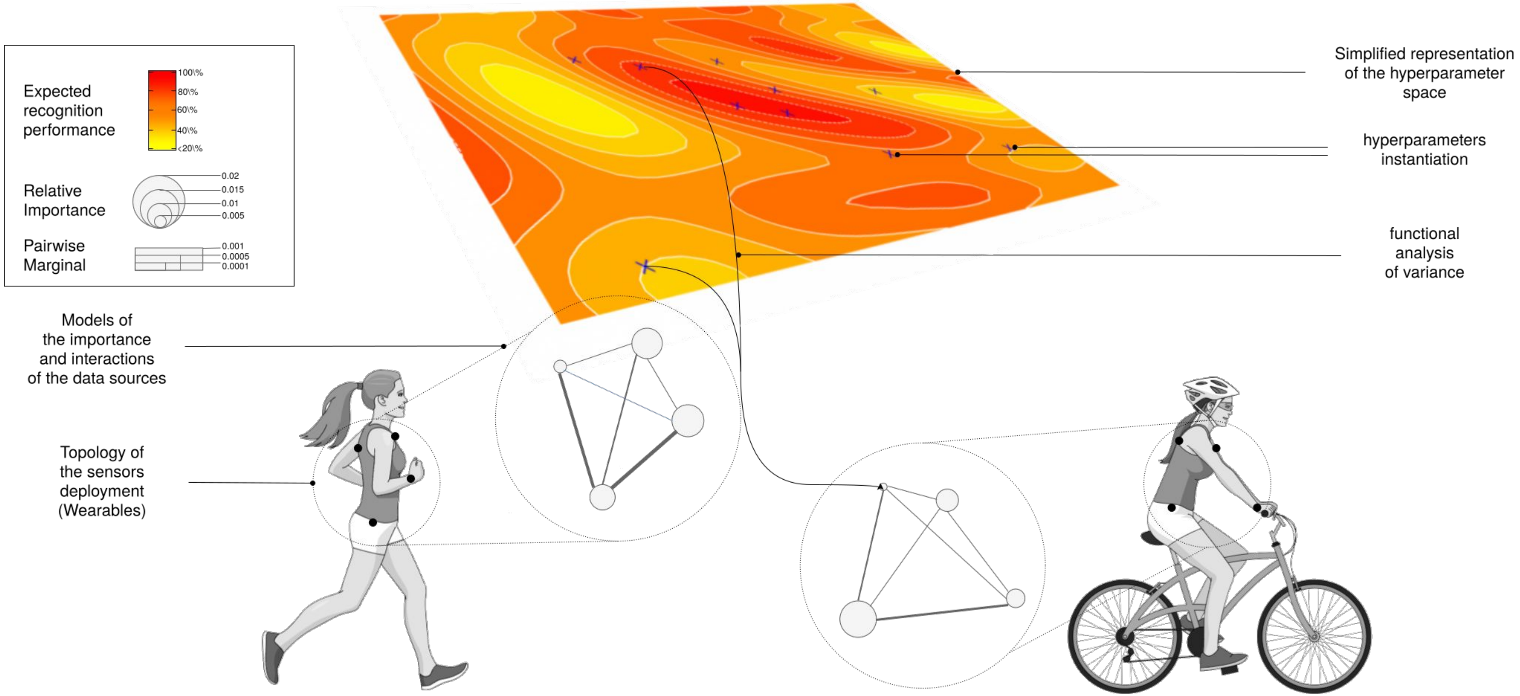
Source: E Brochu, VM Cora, N De Freitas - arXiv preprint arXiv:1012.2599, 2010

Data sources
interactions & importances

- We seek the global influence of the hyperparameters;
- Functional analysis of variance (fANOVA) [Hutter & al. 2014];
- Decomposition of high-dimensional black-box functions into the contribution of their marginal components;
- In our case, the black-box function is the exploration strategy and the marginal components are the hyperparameters;

Frank Hutter, Holger Hoos, and Kevin Leyton-Brown. In: *ICML'14*.

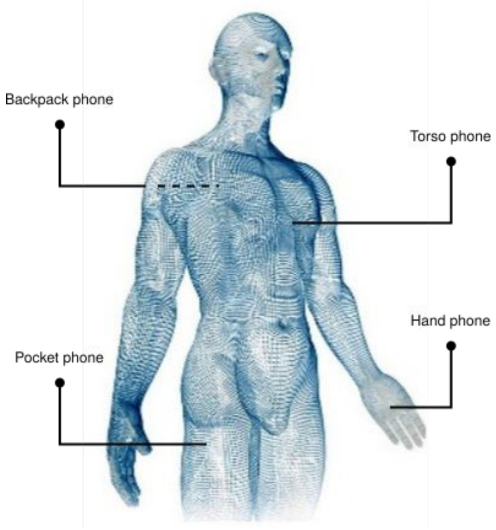
Proposed approach: recap



Experimental setting

- Sussex-Huawei Locomotion Dataset;
- Meta-segmented CV [Hammerla & al.];
- Averaged f1-score;
- Tensorflow, scikit-optimize, fANOVA;

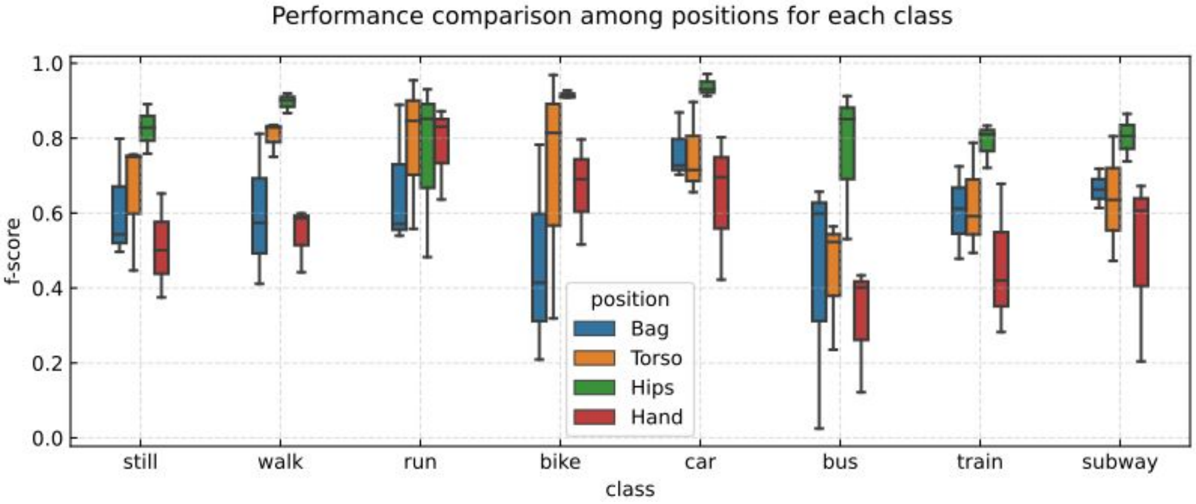
Hyperparam. (sym.)	low	high	prior
Kernel size 1^{st} layer ($ks_{1,mod}$)	9	15	-
Kernel size 2^{nd} layer ($ks_{2,mod}$)	9	15	-
Kernel size 3^{rd} layer ($ks_{3,mod}$)	9	12	-
Number of filters (nf_{mod})	16	28	-
Stride (s_{mod})	0.5	0.6	log
Learning rate (lr)	0.001	0.1	log
Dropout probability (p_d)	0.1	0.5	log
Number of units dense layer (n_u)	64	2048	-



Topology of the sensors deployment

NY Hammerla, T Plötz, in *UbiComp*, 2015

Qualitative evaluation of the interactions model (1)



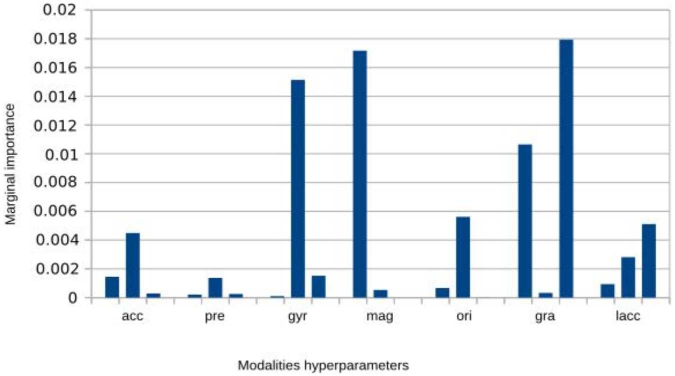
Obtained model exhibits agreement with empirical results in the HAR literature, e.g. Foerster & al. and Mantyjarvi & al.

F Foerster, M Smeja, J Fahrenberg - Computers in Human Behavior, 1999
Mantyjarvi, Jani, & al. *IEEE International Conference on Systems, Man and Cybernetics.* Vol. 2. IEEE, 2001.

Qualitative evaluation of the interactions model (2)

Hyperparam.	Pairwise marginal ($\times 10^{-4}$)
$(ks_{gyr,2}, ks_{gra,2})$	9.2778
$(ks_{mag,1}, ks_{ori,2})$	7.0166
$(ks_{gyr,2}, ks_{ori,2})$	5.5122
$(ks_{acc,1}, ks_{mag,1})$	4.0382
$(ks_{pre,1}, ks_{gyr,3})$	2.3154
$(ks_{gyr,3}, ks_{mag,1})$	2.2472
$(ks_{mag,1}, ks_{ori,1})$	2.1216
$(ks_{pre,3}, ks_{gyr,2})$	1.76305

Most important pairwise marginals of the kernel size hyperparameter



Individual marginal importance of the kernel size hyperparameter

Conclusion & future work

- An original technique for making explicit the interactions among data sources;
- We leverage neural networks capabilities and recent advances in neural architecture search;
- Obtained models exhibits agreement with empirical results in the HAR literature;

- Data augmentation by replacing sensor measurements by random noise;
- Dropping connections that are not important according to the model;
- Adding a sensitivity-based regularization term: a modified term from [Tartaglione & al. 2018] that include, in addition to *parameter-output* sensitivity, an *input-parameter* sensitivity;

E Tartaglione, S Lepsøy, A Fiandrotti, G Francini - Advances in NeurIPS, 2018