Evaluating surgical skills from kinematic data using convolutional neural networks

Fawaz, H. I., Forestier, G., Weber, J., Idoumghar, L., & Muller, P. A. (2018). Evaluating surgical skills from kinematic data using convolutional neural networks. *arXiv preprint arXiv:1806.02750*.

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Background

- ‘See one, do one, teach one’ – subjective, high-cost
- Checklist - subjective
- Global movement features (completion time, smoothness)-no detailed feedback
- Videos and kinematic variables
  - Lack of interpretable result
  - Predefined gesture boundaries

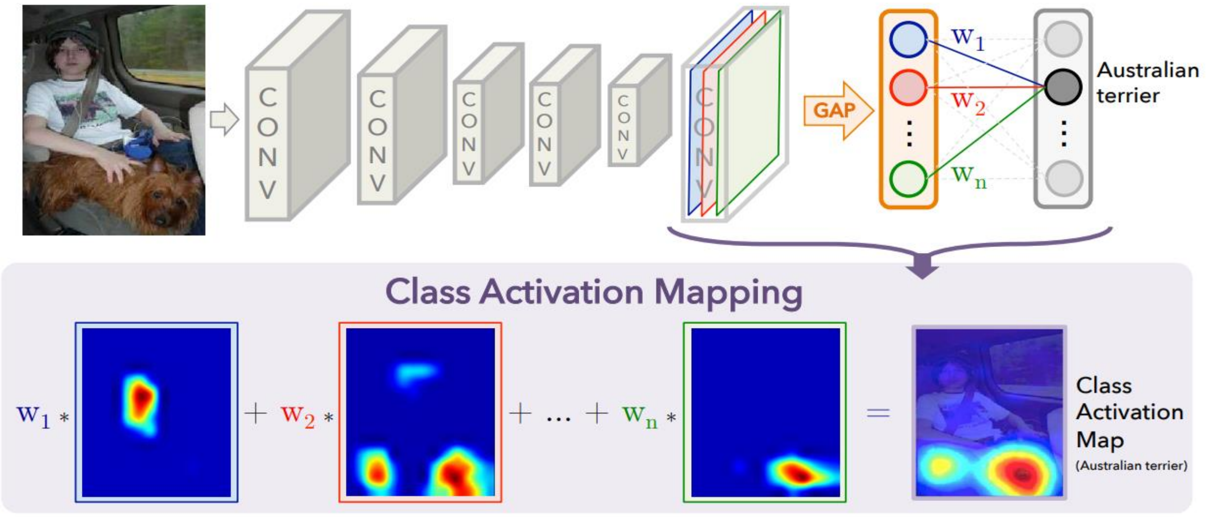
Dataset

- JIGSAWS: 8 subjects, 3 skill levels, three different surgical tasks (suturing, needle passing and knot tying), five trials. 40 trials in total

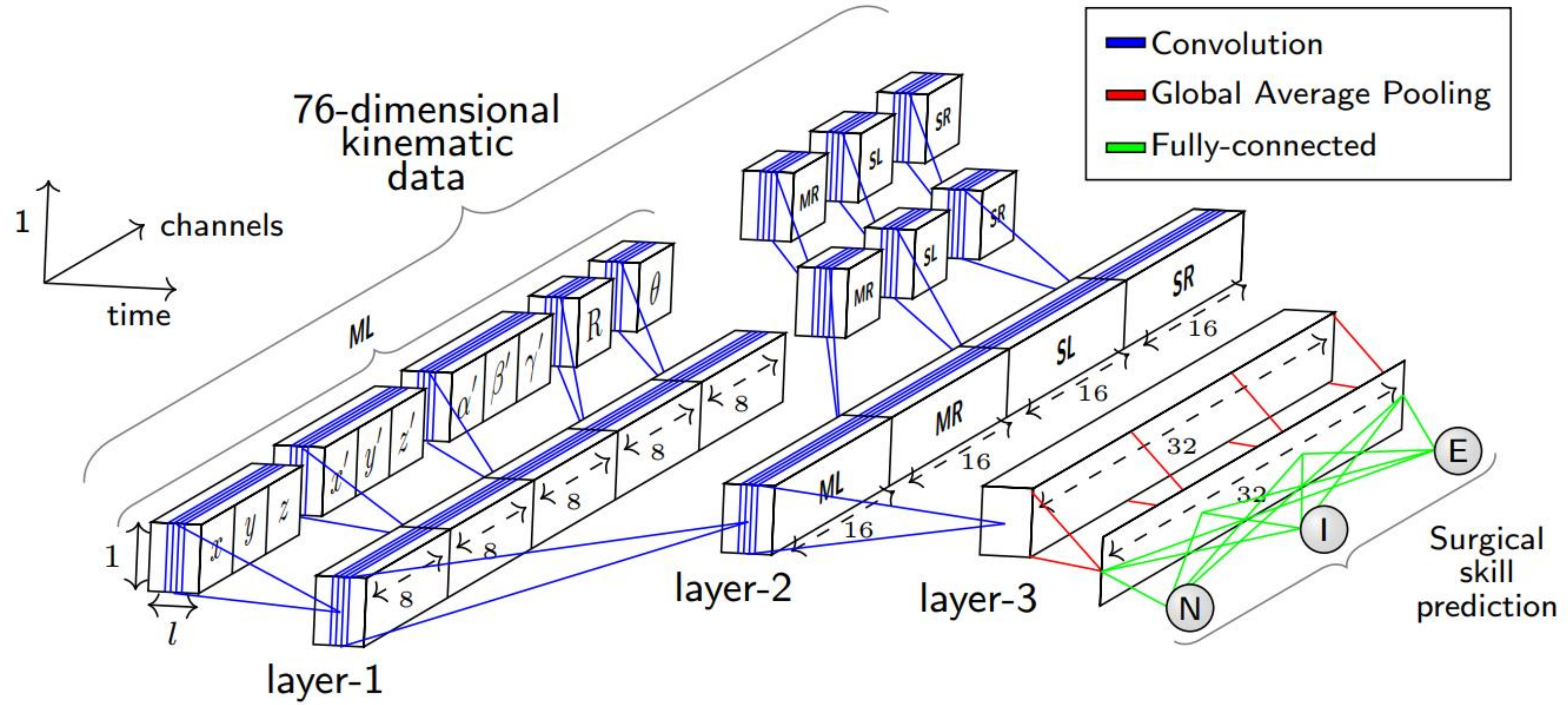
Training & testing

- Cost function: multinomial cross-entropy with l2 regularization (for overfitting)
- Optimization: Adam, lr = 0.001
- Training epochs: 1000 epochs saving the best
- Validation: Leave one super trial out (LOSO): for each iteration of cross-validation (five in total), one trial of each subject was left out for the test and the remaining trials were used for training.

Class activation map

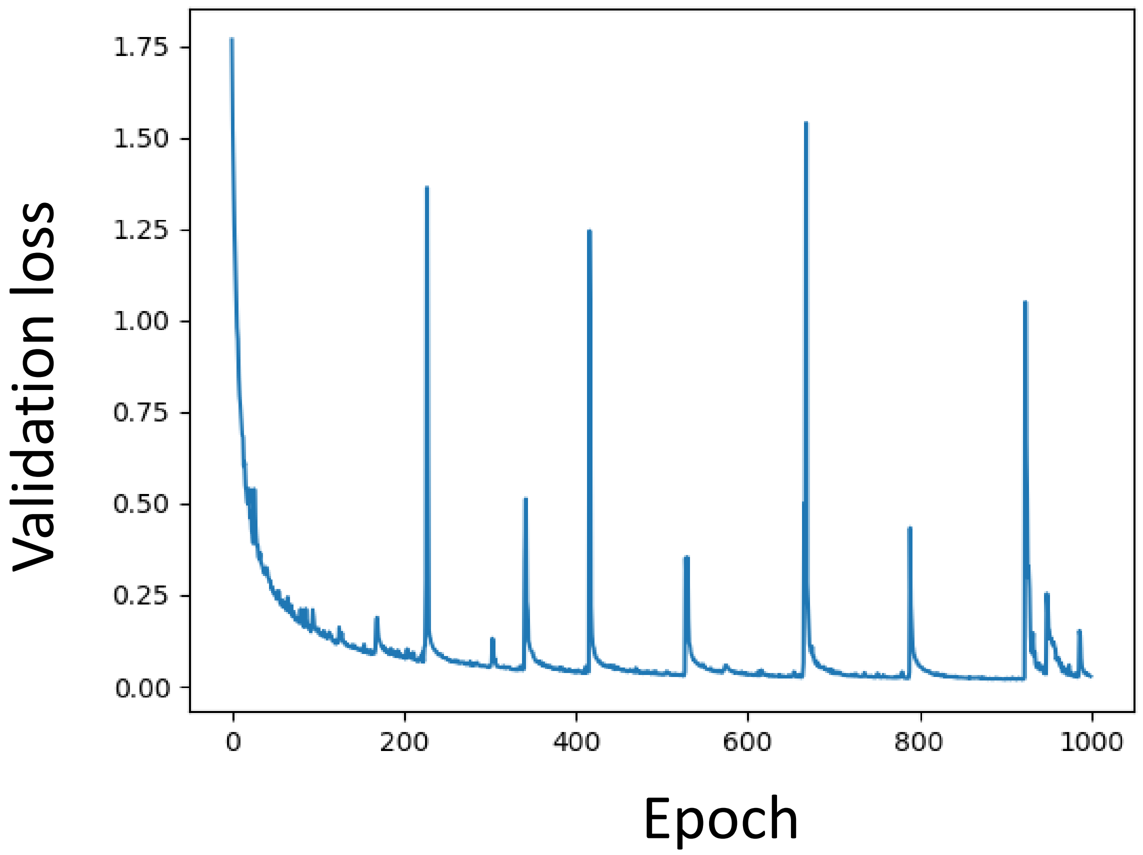


Architecture



Training

Total params = 16K
Train size: 23
Val size: 8
Test size: 8
The only thing they did for over-fitting is l2 regularization



Result – surgical skill classification

Table 1: Surgical skill classification results (%)

Method	Suturing		Needle Passing		Knot Tying	
	Micro	Macro	Micro	Macro	Micro	Macro
S-HMM [13]	97.4	n/a	96.2	n/a	94.4	n/a
ApEn [19]	**100**	n/a	**100**	n/a	**99.9**	n/a
Sax-Vsm [4]	89.7	86.7	96.3	95.8	61.1	53.3
CNN (proposed)	**100**	**100**	**100**	**100**	92.1	**93.2**

Result – feedback visualization