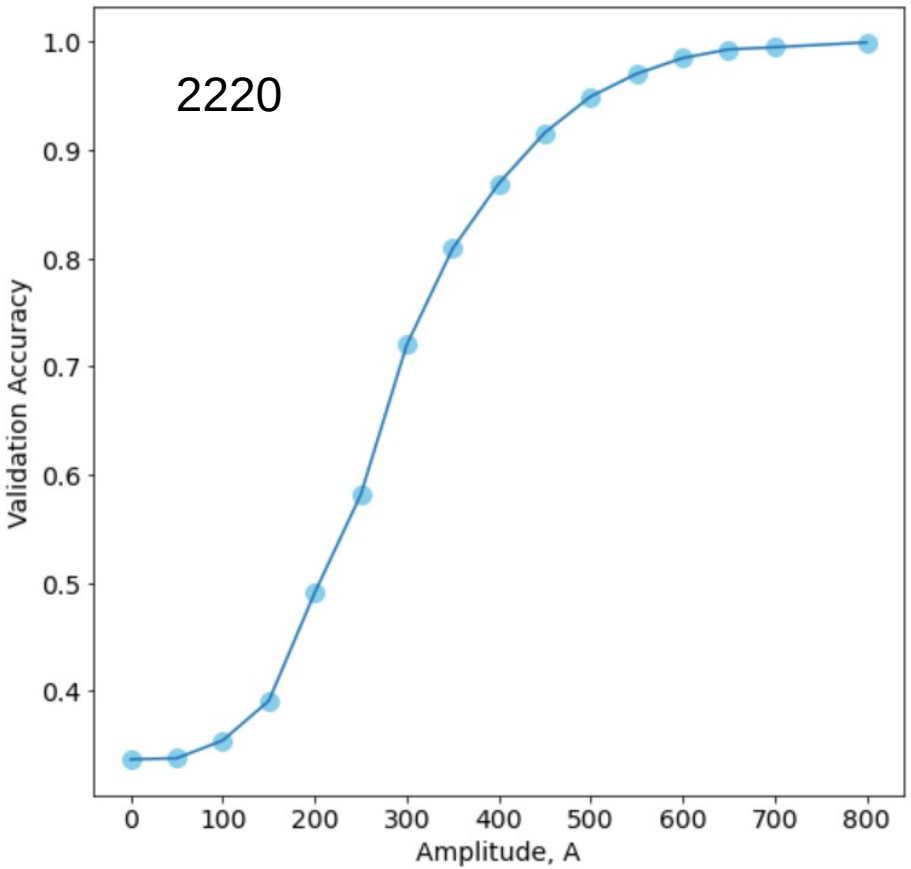
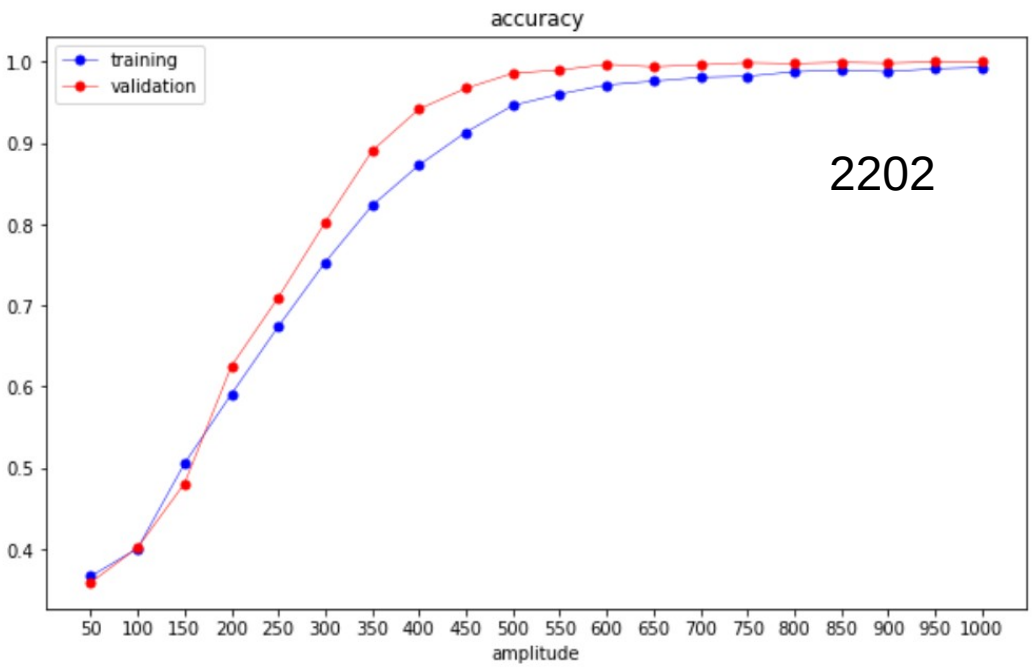
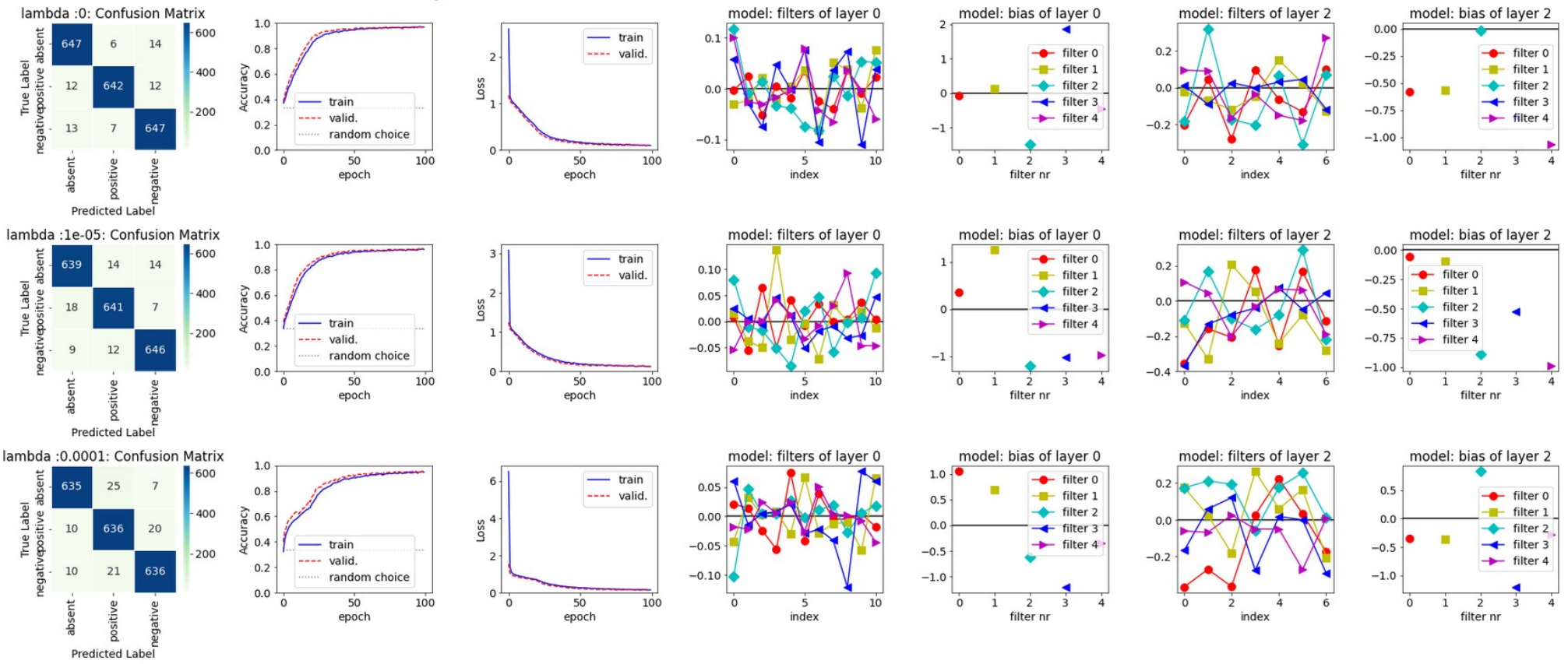
Convolutional Neural Network (CNN)

Accuracy vs amplitude *A*

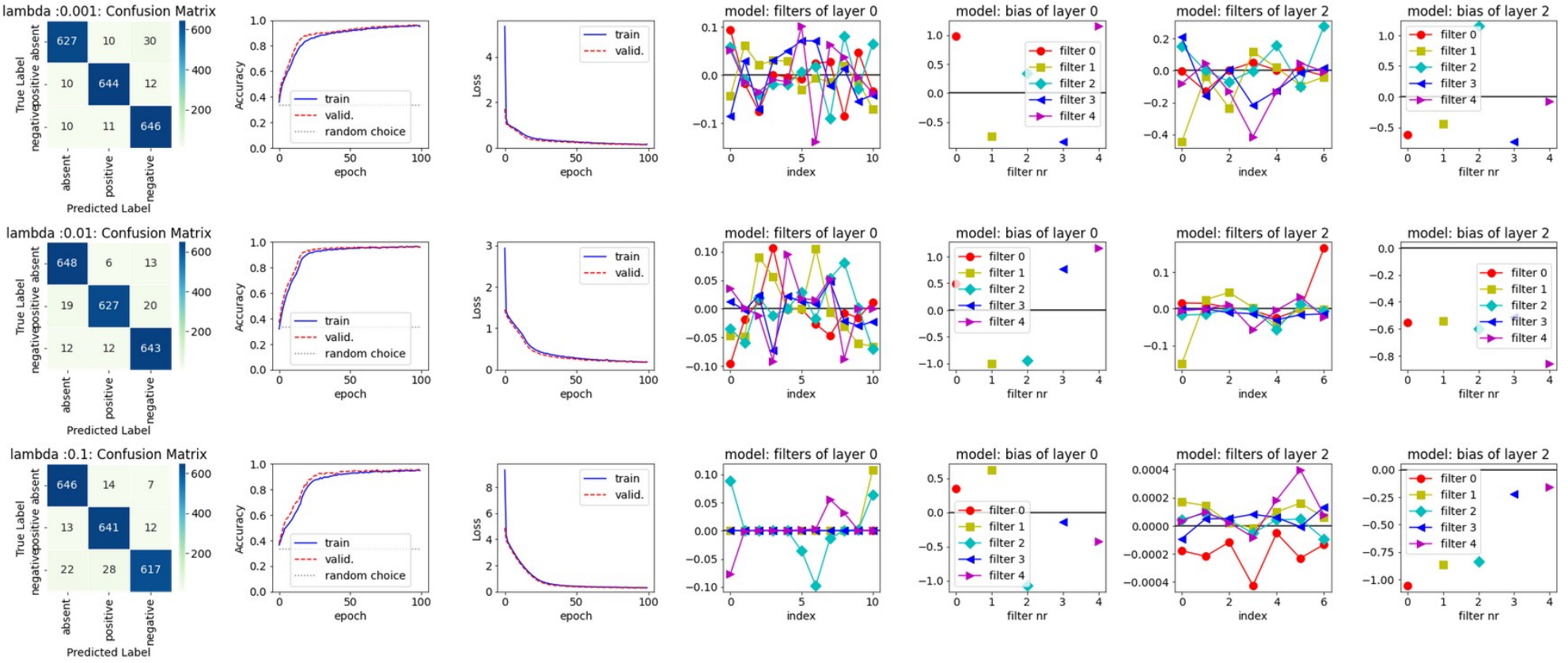




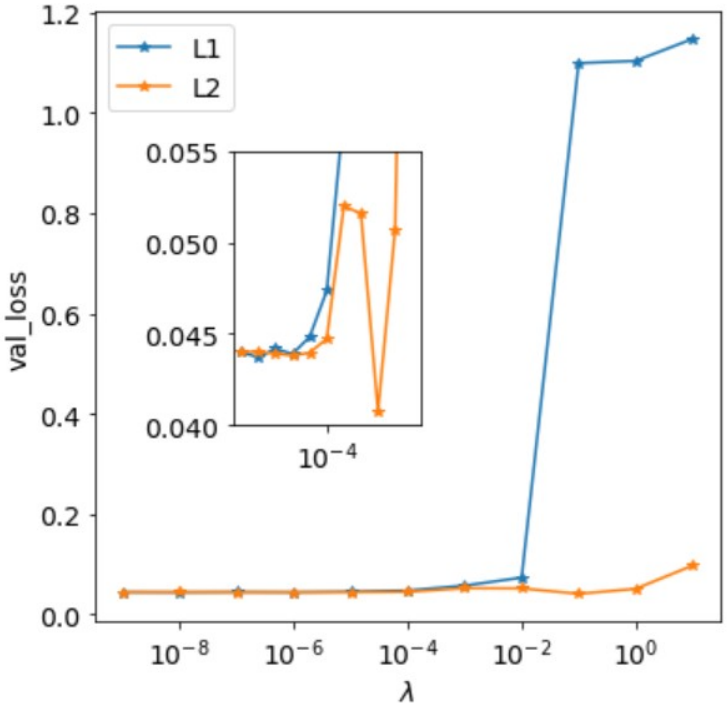
Accuracy vs lambda (Ridge reg.)



Accuracy vs lambda (Ridge reg.)



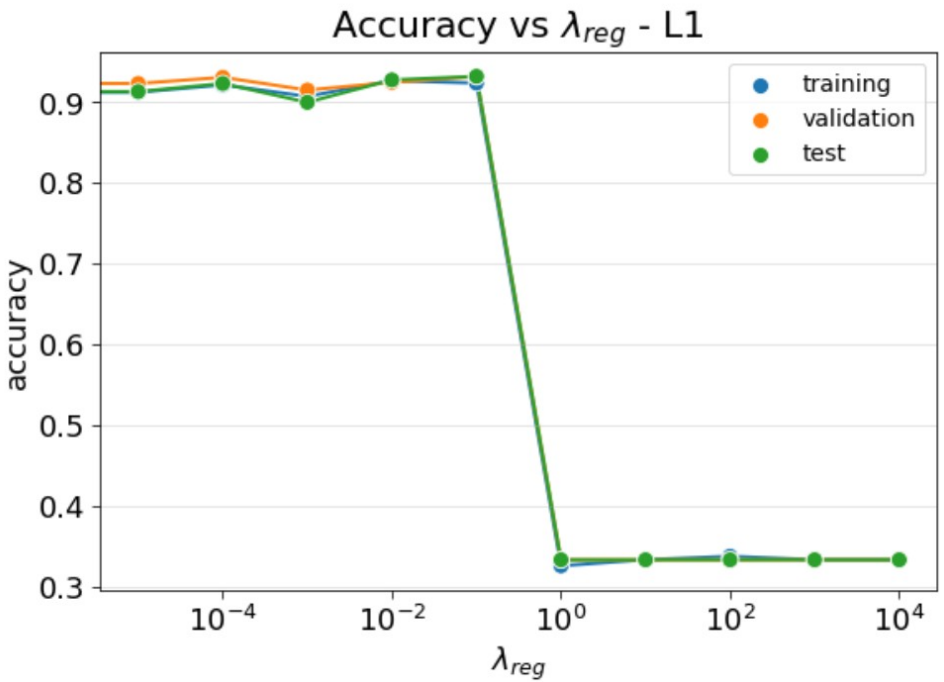
Accuracy vs regularization

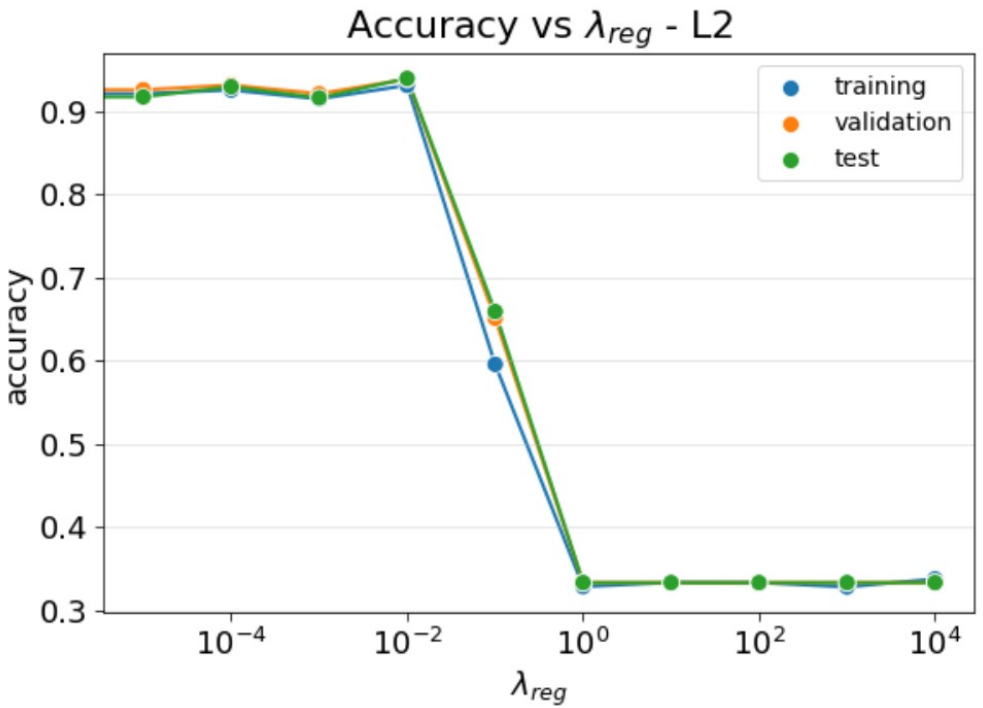


We notice that the RIDGE L2 regularizer has best performance (smallest loss function value at the end of the training) for an intermediate value of regularization strength, $\lambda \sim 10^{-1}$ in this case, although some variation is observed among different runs of the trainings (see inset in the previous plot); however, the performance of the model with such regularizer are comparable over many of the tested orders of magnitude for λ: the performance starts getting degraded only for $\lambda > 1$. The learnt masks, with the L2 regularizer and $\lambda < 10^{-1}$ exhibit a sinusoidal shape with different periodicity from the added pattern; notice that this is the case also for the best performing λ value. For larger λ the width of the masks replicates better the one of the added pattern, but, as anticipated, the performance is actually worse.

The L1 regularizer, instead, has decreasing performance with increasing λ in a roughly monotonic way; in fact, although in the shown run the loss exhibits a minimum at $\lambda \sim 10^{-8}$, we obtained a large variability in different runs, therefore its actual existence should be investigated more thoroughly. In general, however, the trend we observe is a progressive degradation of performance for increasing λ with the L1 regularizer. Also in this case, for small λ, the learnt masks are sinusoidal. For large λ, instead, the performance of the CNN drops abruptly. The learnt filters do not replicate the pattern and the modulus of the weights becomes very small. This is in line with our expectations: the LASSO regularizer is expected to give sparse results, particularly for large regularizations strengths.

Accuracy vs regularization





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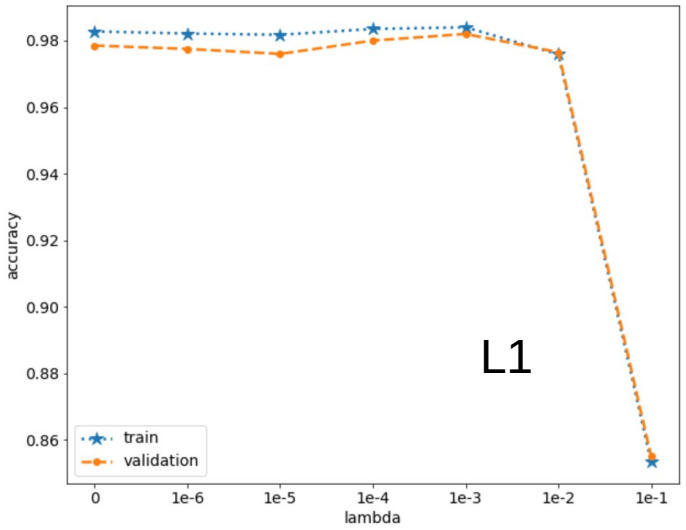
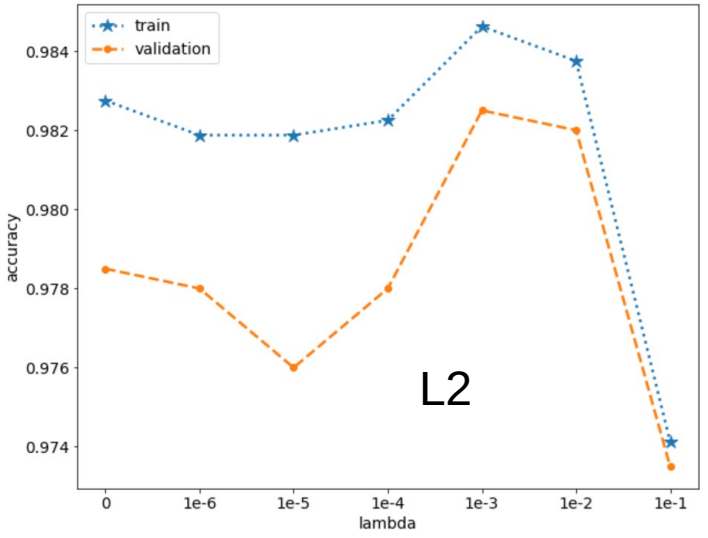
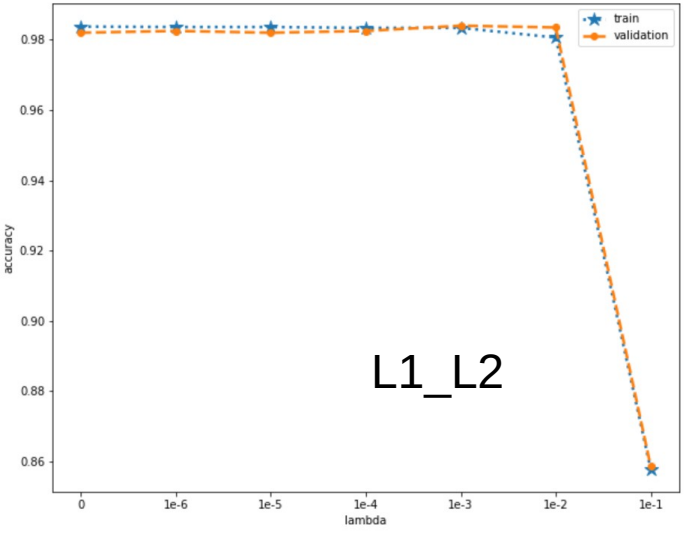
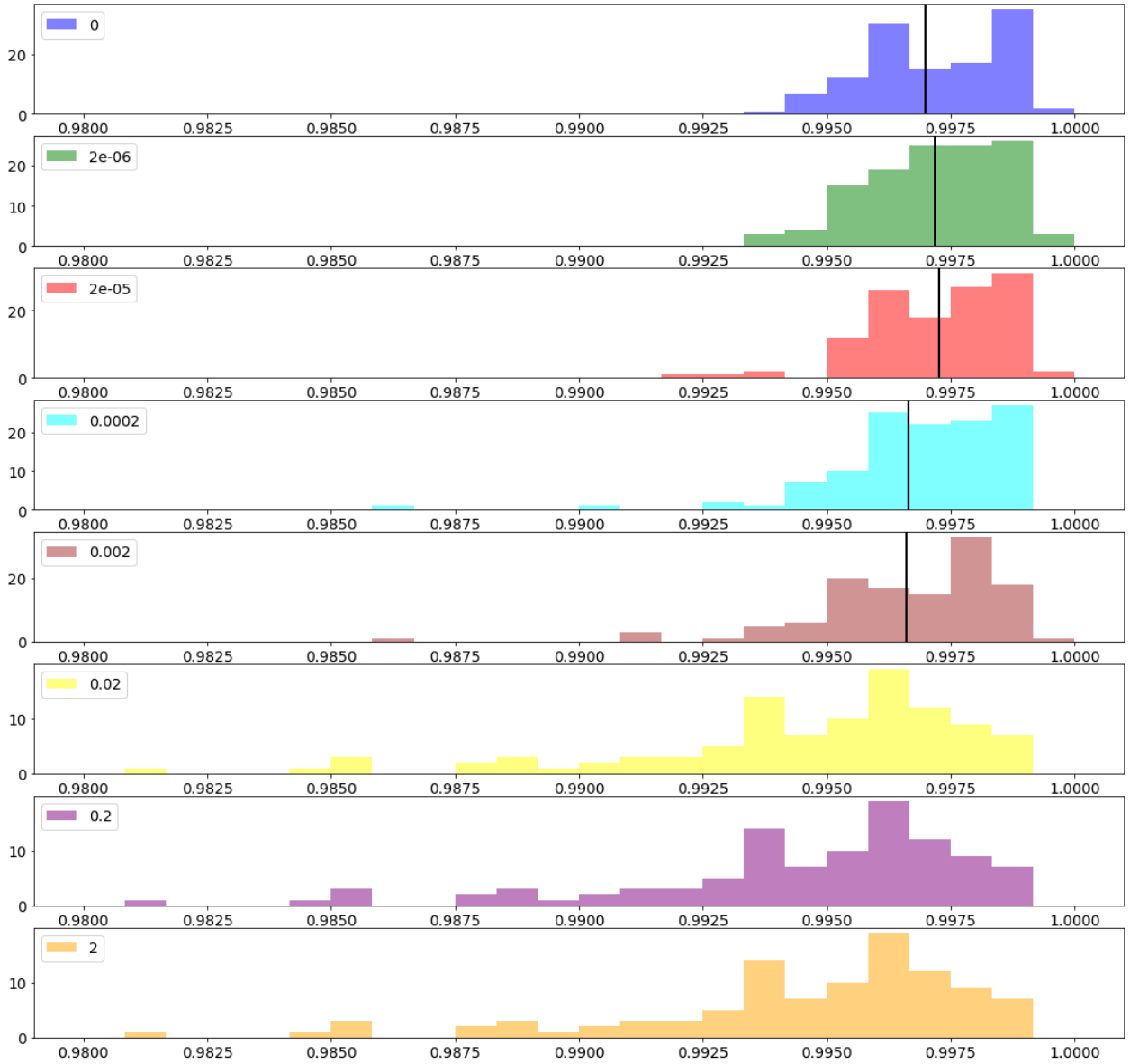
Accuracy vs regularization







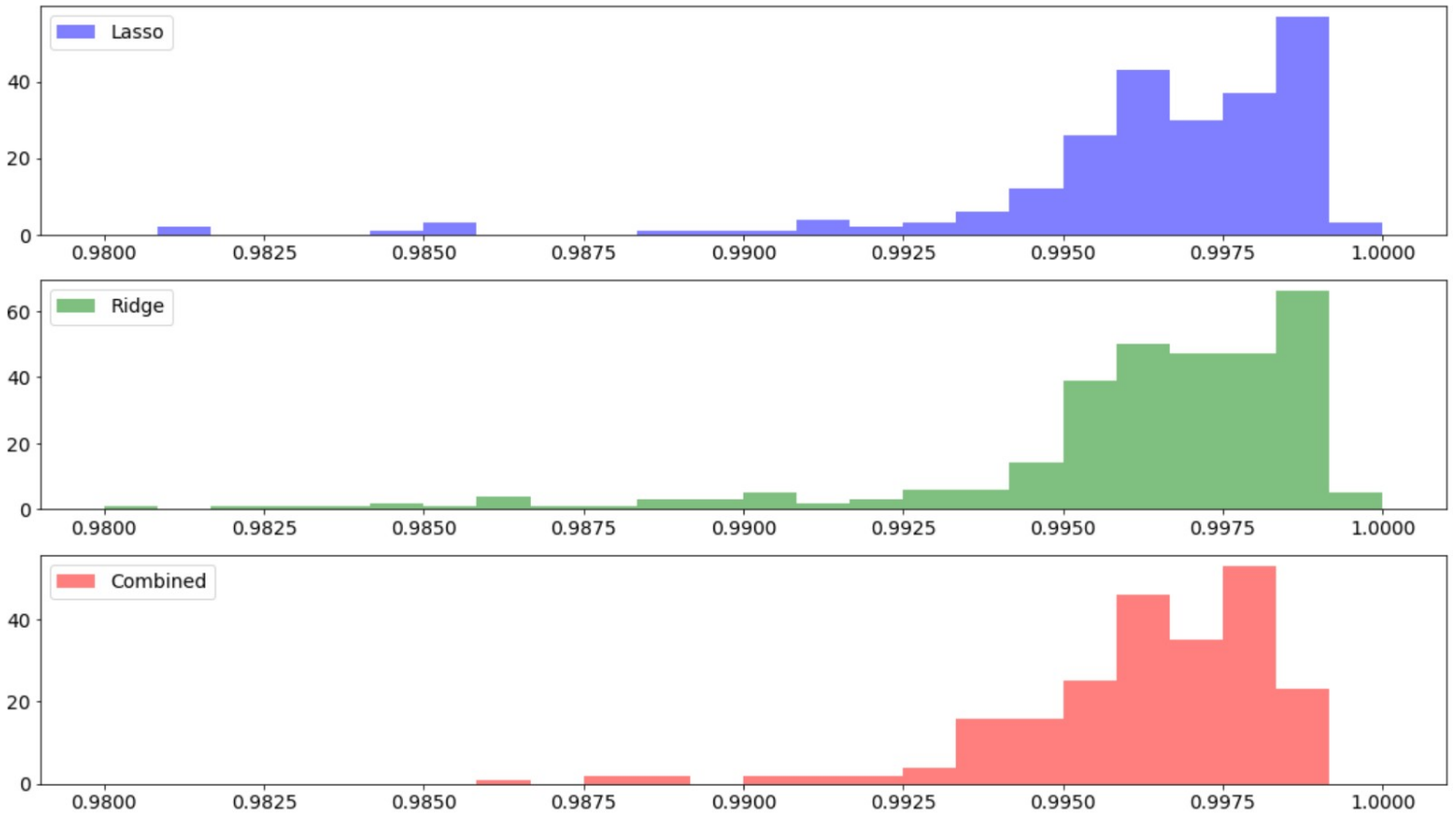
2221



Accuracy vs regularization

2202

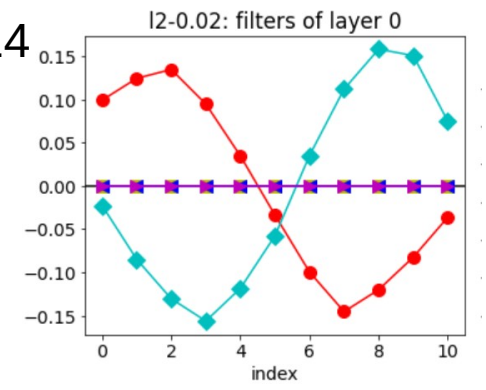
Accuracy vs regularization

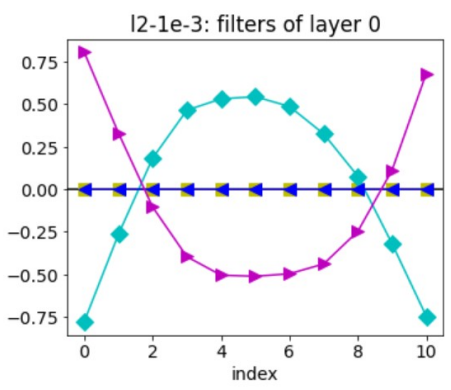


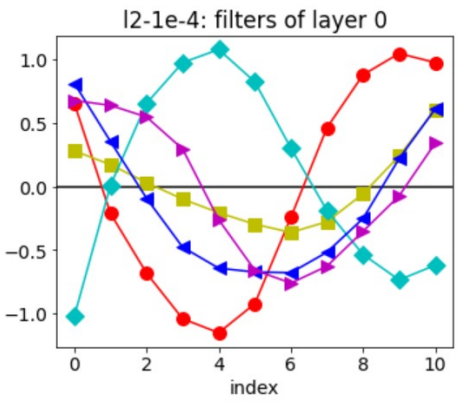
2202

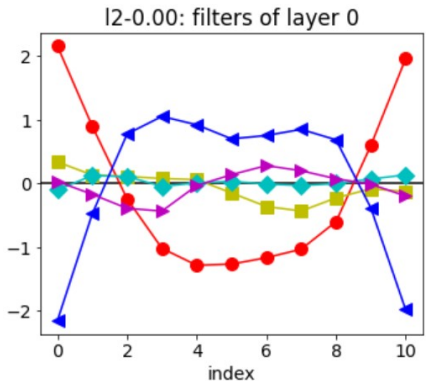
Regularization: effect of lambda varying from different simulation?

2214

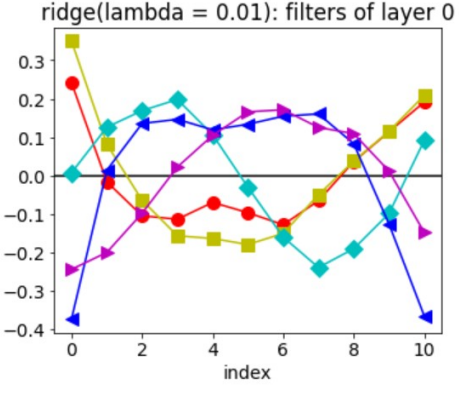


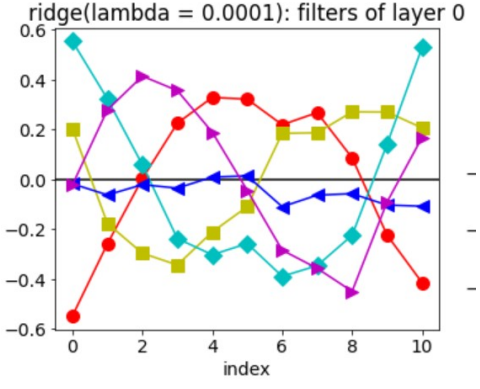






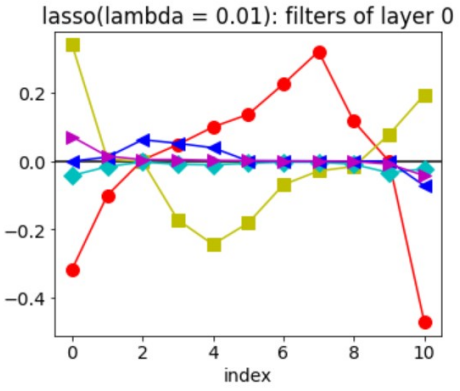
2215

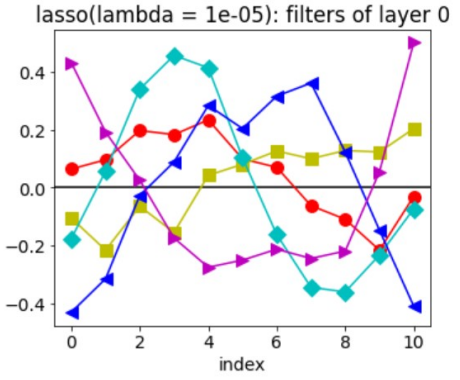




Regularization: effect of lambda varying from different simulation?

2215

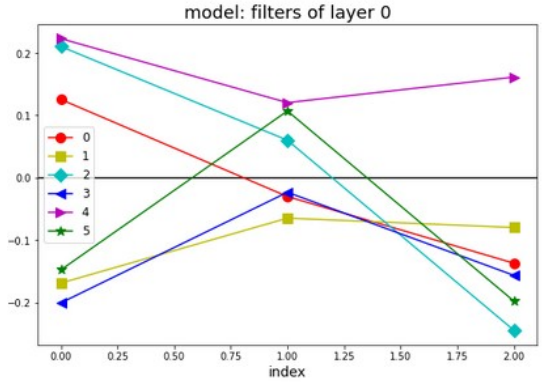


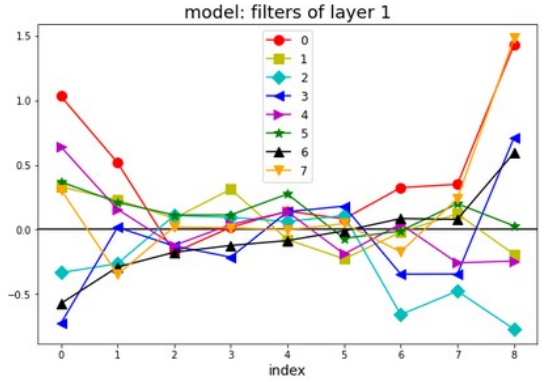


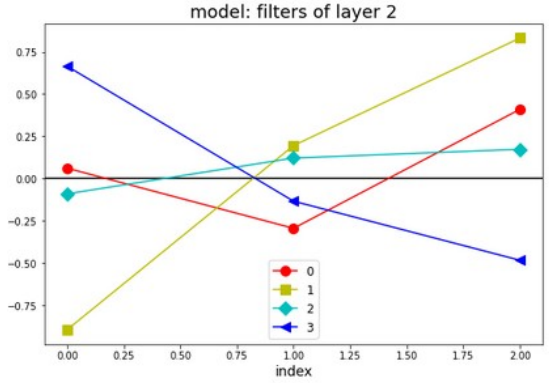
2021 model (maxpooling)

2202

The model with the three convolutional layers followed by the global pooling has a very good performance: the accuracy of both training and validation is higher than 99%. It converges in a stable way and in a low number of epochs, even when using small batch sizes. Therefore, the suggested model is successful on a 2-dimensional time series. This result makes perfect sense: with this structure, the network focuses only on detecting the presence of the pattern, disregarding its position, and the sizes of the filters are adequate for detecting the pattern.







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2021 model (maxpooling)

Is it working better?

->This model performs slightly better than the ones previously tested.

If yes, which could be the reason?

->We think the better performance can be adressed to the use of GlobalMaxPooling over AveragePooling,