Structural Damage Classifications for Post-Earthquake Recovery

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ABSTRACT

Recent studies in the field of structural engineering raise eyes on the importance of post-earthquake recovery in urban areas. With the modern remote sensing technology, building and structural component images become accessible via aerial drones or related devices. In this project, the state-of-the-art deep learning technology for a civil engineering application is implemented, namely recognition of structural damage from images.

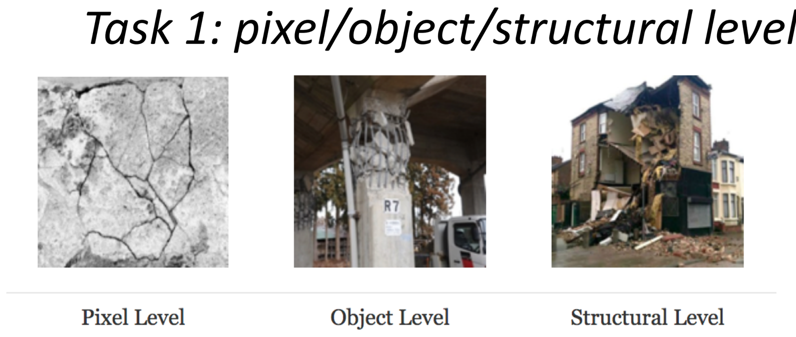
PROBLEM STATEMENT

PEER PHI Kaggle Competition

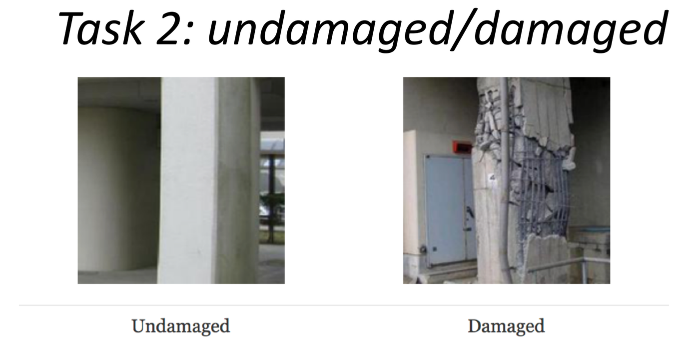
The big potential in deep learning application in structural engineering prompts the Kaggle Competition - "PEER Hub ImageNet Challenge" held by University of California at Berkeley. Totally 8 classification tasks are raised.

Eight Classification Tasks

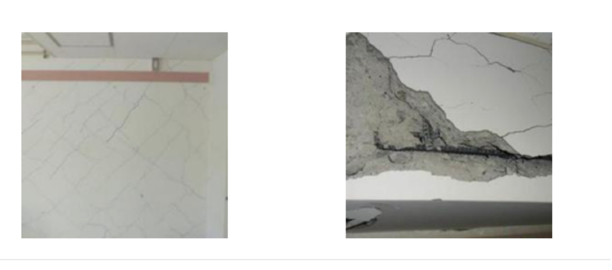
Task 1: pixel/object/structural levels



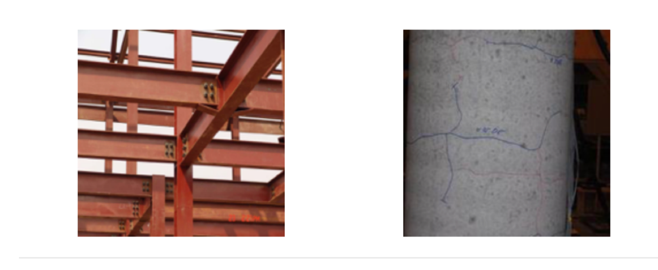
Task 2: undamaged/damaged



Task 3: no spalling/spalling

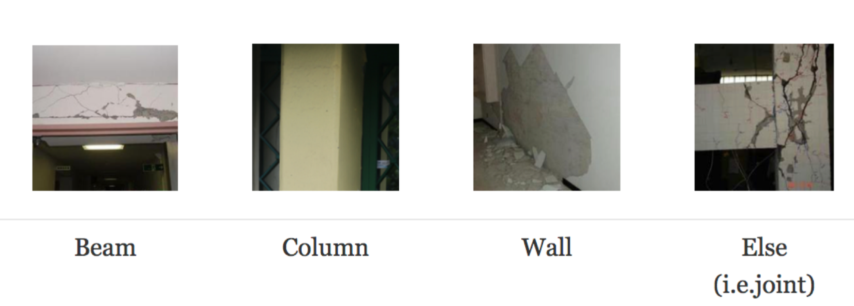


Task 4: steel/others

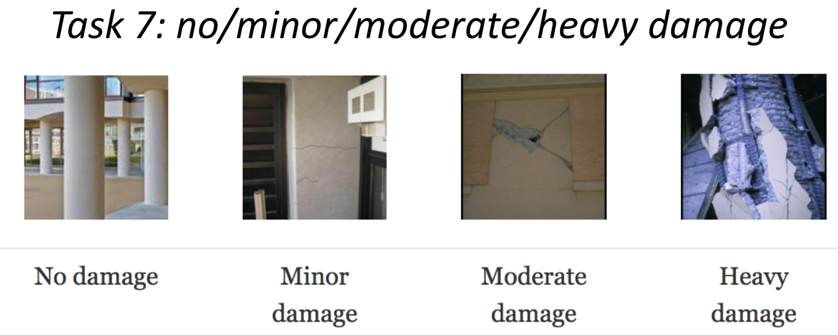


Task 5: no/partial collapse/collapse

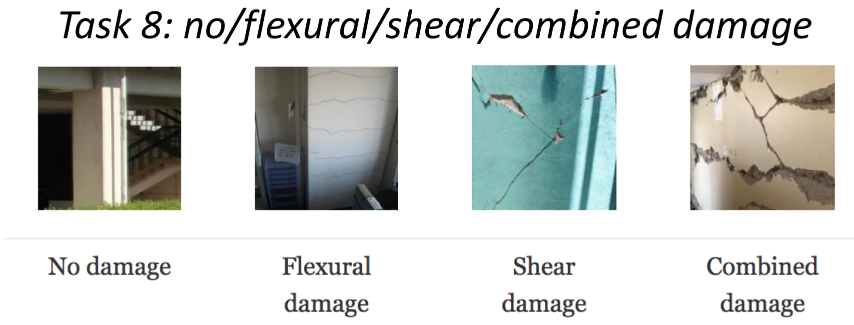
Task 6: beam/column/wall/else



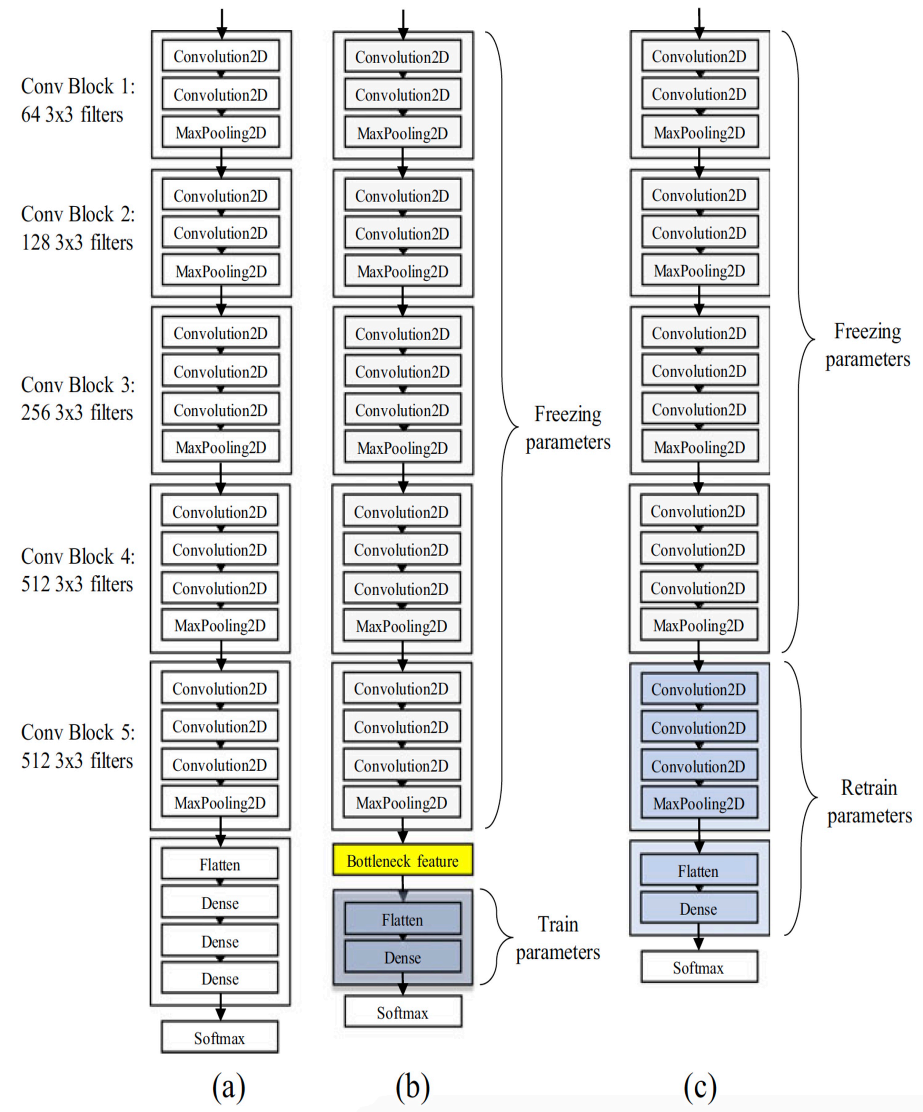
Task 7: no/minor/moderate/heavy damage



Task 8: no/flexural/shear/combined damage



GENERAL APPROACH

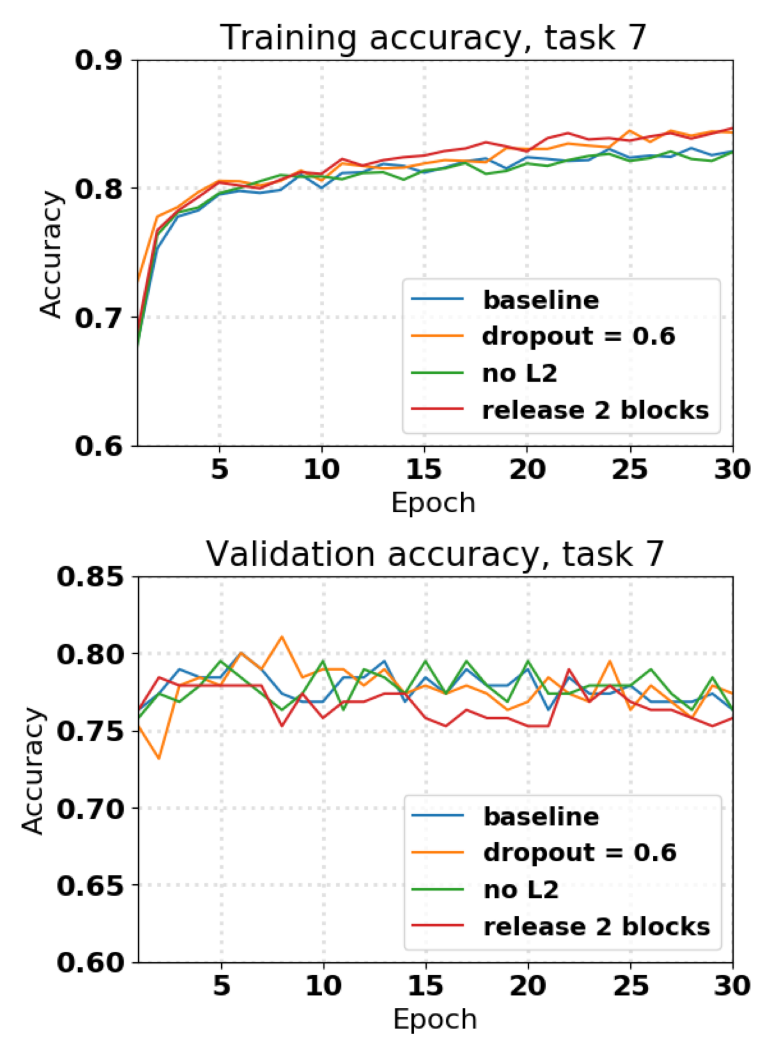


For tasks (1, 2, 3 and 4) with sufficient data, we choose VGG-16 as our baseline model for transfer learning. The first step is to extract the bottleneck features and train one new-added layer with them (as in "b"). Then, by releasing the higher level conv-blocks, we "fine-tune" the model to better fit each tasks (shown in "c").

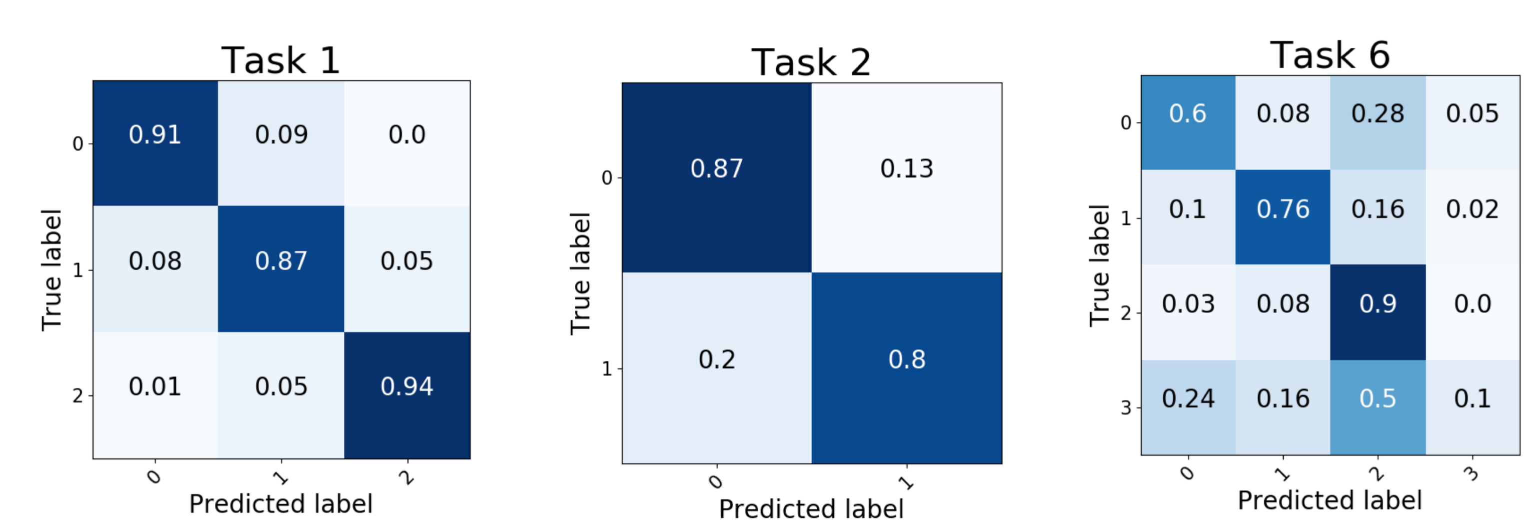
PARARMETER TUNING AND RESULTS

Hyperparameter explored:

- # of Conv blocks frozen
- L2 regularization
- Dropout rate
- Learning rate decay
- Data augmentations
- Batch sizes
- Adam / SGD

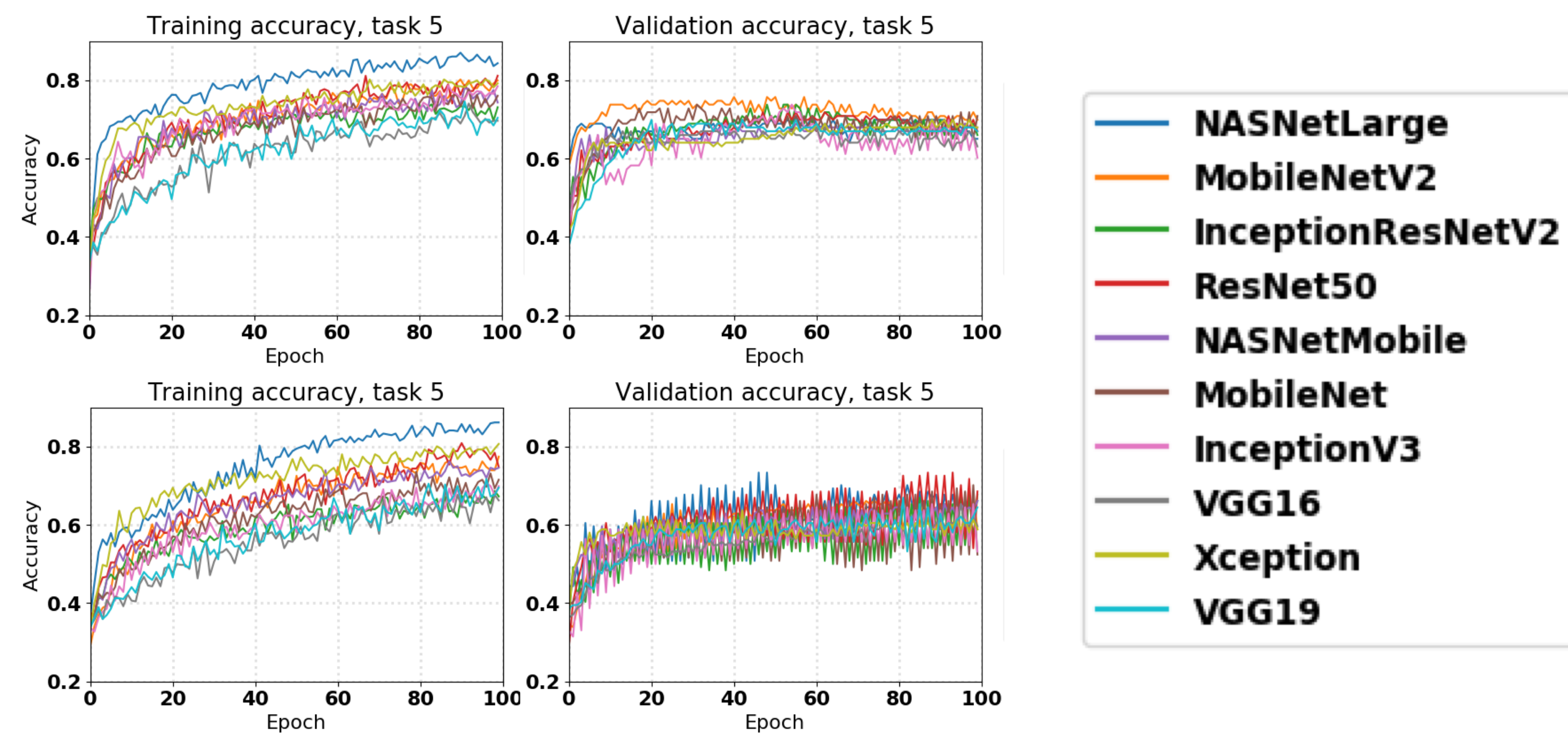


The number of conv blocks frozen depends on the amount of data available in each tasks.



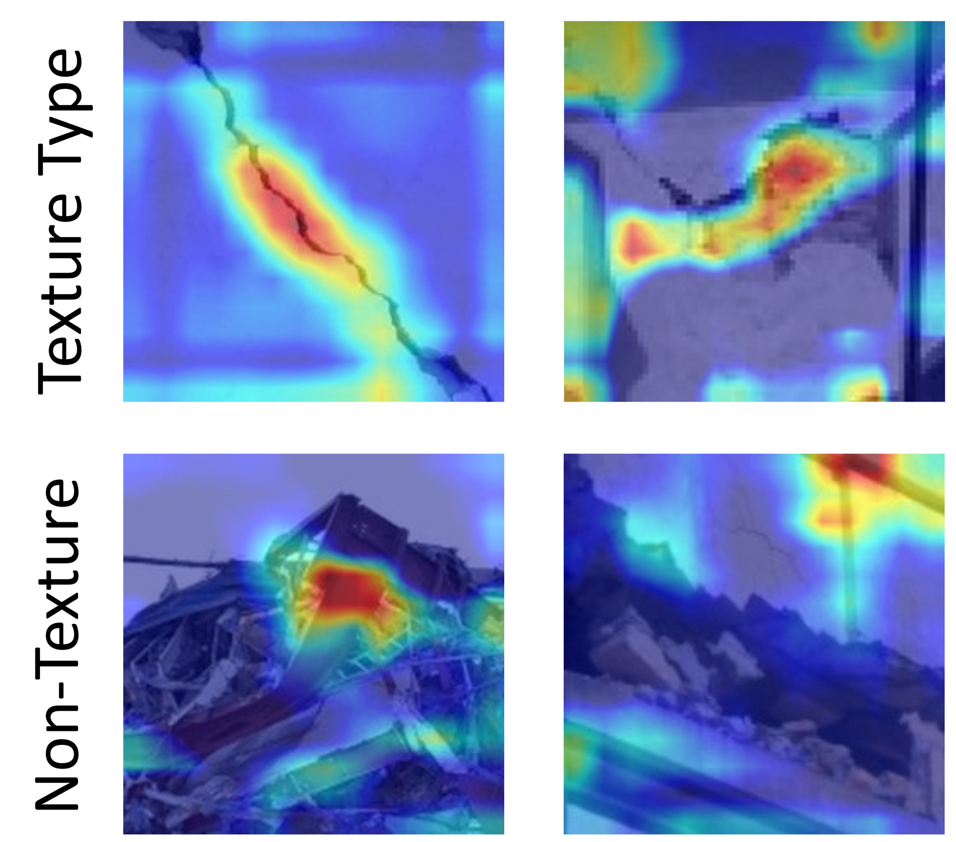
FINAL TRIALS AND EXPERIMENTAL RESULTS

Multi-model Training and Oversampling Data



In the final phase of the competition, we tried different deep learning architectures and average the learning results at softmax layers to improve performance. The effect is significant for the tasks with smaller datasets (task 5, 6, 7 and 8). Also, the oversampling technique is applied in tasks with highly imbalanced data.

Fancy PCA and Class Activation Map



In order to further improve on performance, we tried Fancy PCA as one of our data augmentation methods. It is found to be effective on "texture-type" classification, such as damage/no damage and spalling/no spalling. For other tasks, the improvement is not significant. CAM is used to visualize the influence.

CONCLUSIONS AND FUTURE WORK

The combination of modalities is found effective in improving the performance of small dataset. With in-depth hyperparameter tuning with VGG16 and Multi-model training, we rank at ~15% among other competitors. There is space to improve by tuning parameters in the multi-model method.