

Material Classification on Construction Sites

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Overview

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3. Method
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 - b. Classification of materials
4. Results
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Motivation

- Applying artificial intelligence to increase the digitization of the construction process
- Increase efficiency and transparency of construction processes
- Track progress of construction sites by analyzing surface materials in images



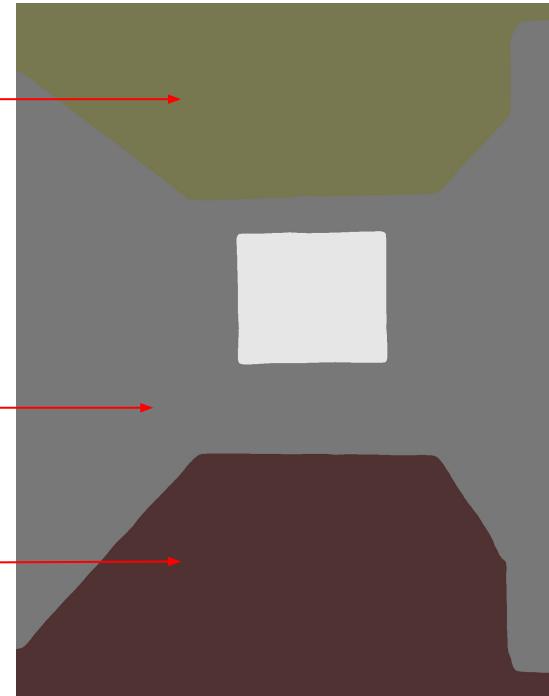
Task - 1. Segmentation



Ceiling

Wall

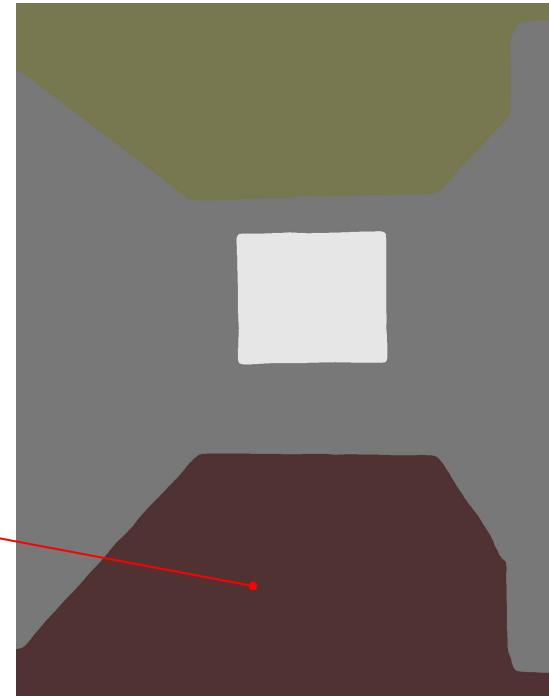
Floor



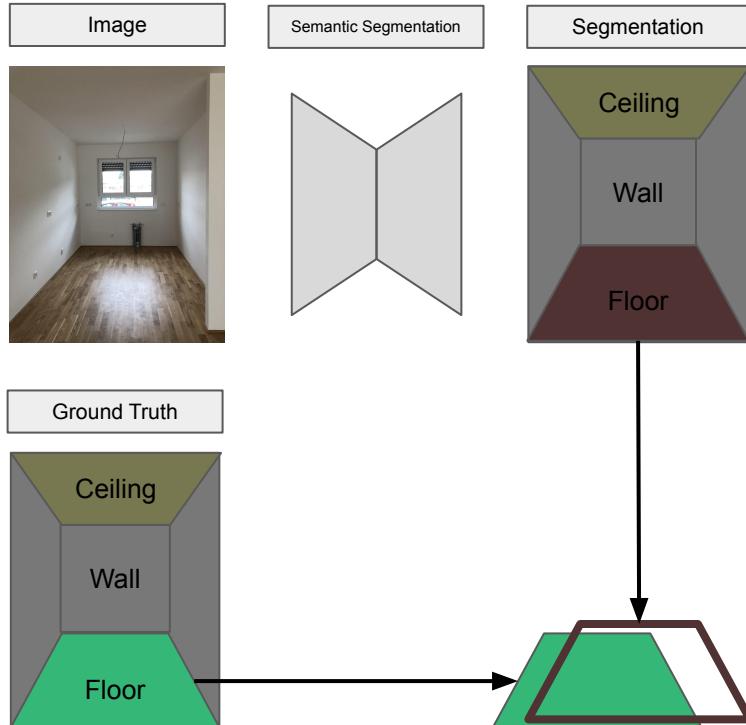
Task - 2. Segment Material Classification



Wood



Method - Semantic Segmentation

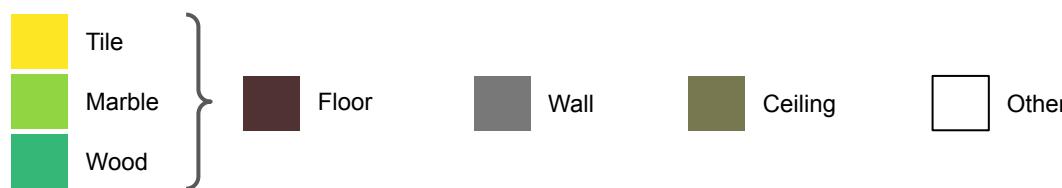


- Semantic segmentation:
 - Deeplab V3+*
 - HRNet V2**
- Pretrained on **ADE20k** dataset:
 - >20000 segmented images of in- & outdoor scenes
 - 150 semantic categories
 - Used *Ceiling, Wall & Floor*
- How well do they perform on segmenting construction site images?

*<https://arxiv.org/abs/1802.02611>
**<https://arxiv.org/pdf/1608.05442.pdf>

Evaluation Dataset

- 61 images of a renovated flat
- ground truth segmentation was performed by us

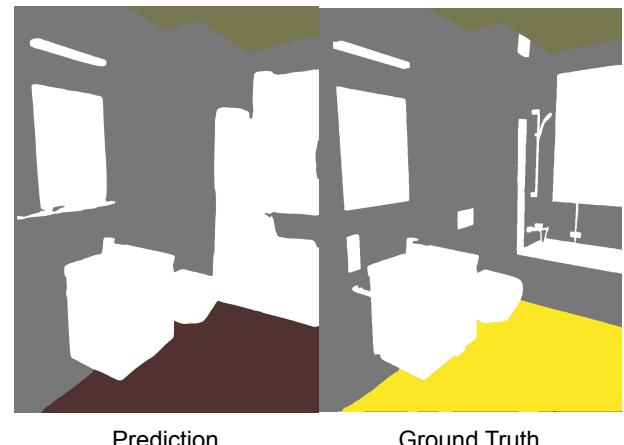


Semantic Segmentation - Quantitative Results

Benchmarked **pretrained** (on ADE20k dataset)
state of the art image segmentation models on
our evaluation dataset (61 images)

	Deeplab V3+	HRNet V2
Ceiling mIoU*	62.65 %	63.82 %
Wall mIoU*	84.16 %	81.11 %
Floor mIoU*	90.86 %	89.83 %
Average mIoU*	79.21 %	78.25 %

Rohbau (deeplab)
Ceiling mIoU: 45.32753492493375
Wall mIoU: 75.57315123318288
Floor mIoU: 65.3497364034332
Average mIoU:
62.08347418718328



*mean Intersection over Union (mIoU)

Semantic Segmentation - Qualitative Results

- Positive examples:



Semantic Segmentation - Qualitative Results

- Negative examples:



Floor



Wall



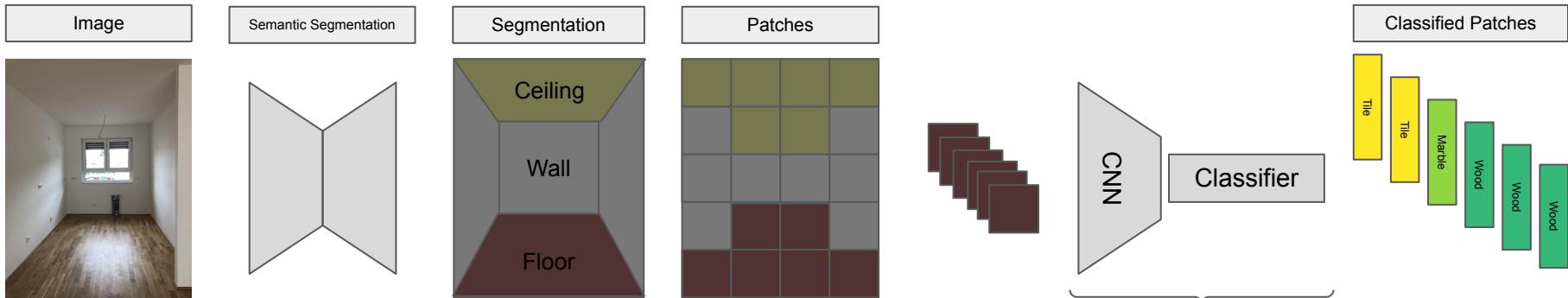
Ceiling



Other

Method - Segment Material Classification

adapted from Schmidhuber2012*:



- Configuration and hyperparameters:
 - Pre-trained models on ImageNet
 - Training and supervision using PyTorch and W&B
 - Used two different optimizers:
 - SGD ($lr=0.1$ with ReduceLROnPlateau scheduler)
 - Adam ($lr=0.001$)
 - Trained for 50 epochs until model converged
 - Batchsize was set to 32



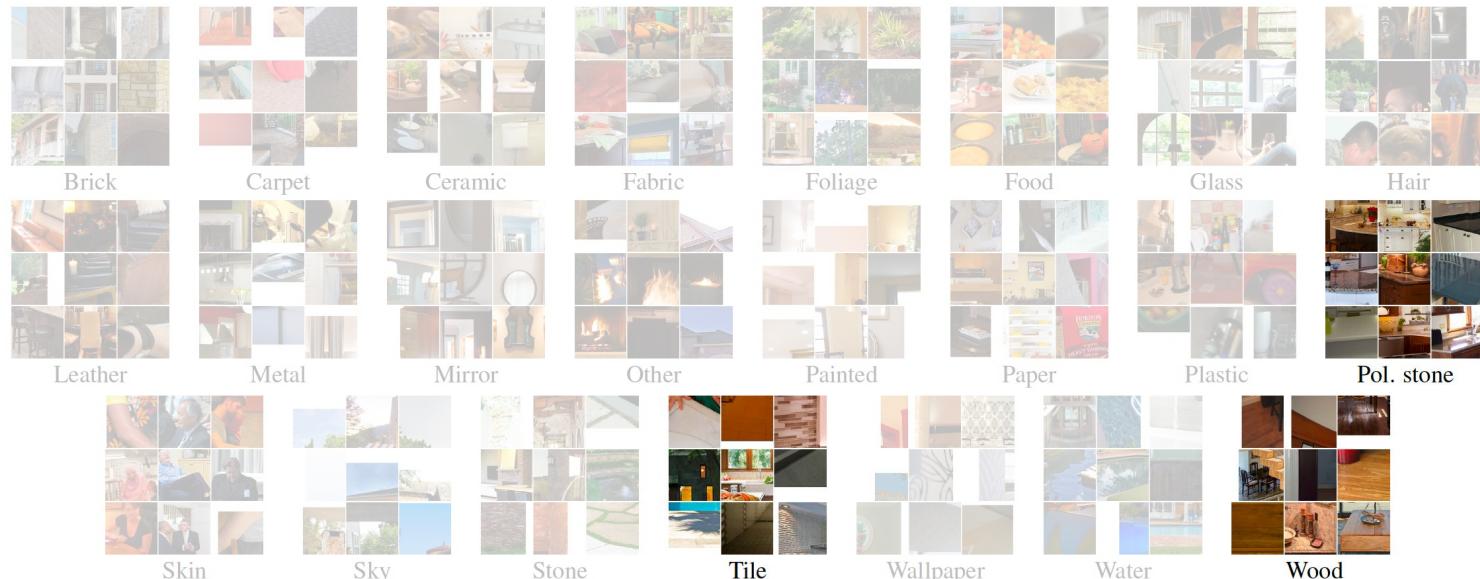
Used network architectures:

- EfficientNet** ('b1')
- Wide ResNet*** ('50_2')

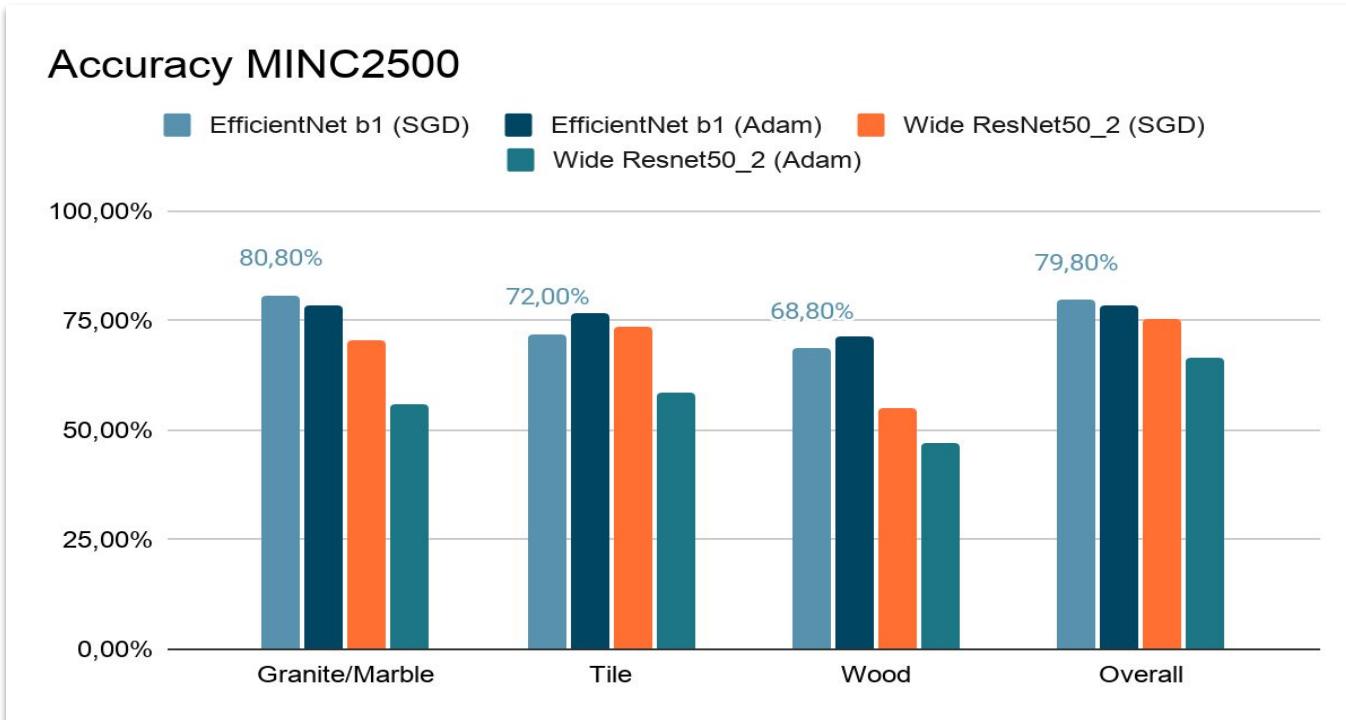
*<https://people.idsia.ch/~juergen/nips2012.pdf>
**<https://arxiv.org/pdf/1905.11946.pdf>
***<https://arxiv.org/pdf/1605.07146.pdf>

Datasets for Classification: MINC-2500

- 2500 images per class (used a 80/20 split for training/eval)
- 23 classes (we used only 3):

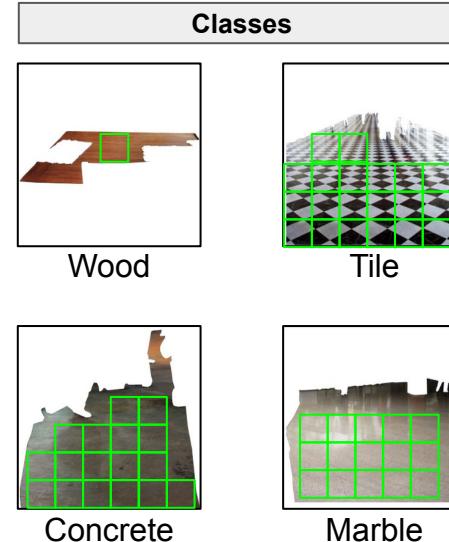


Material Classification - Training and Evaluation

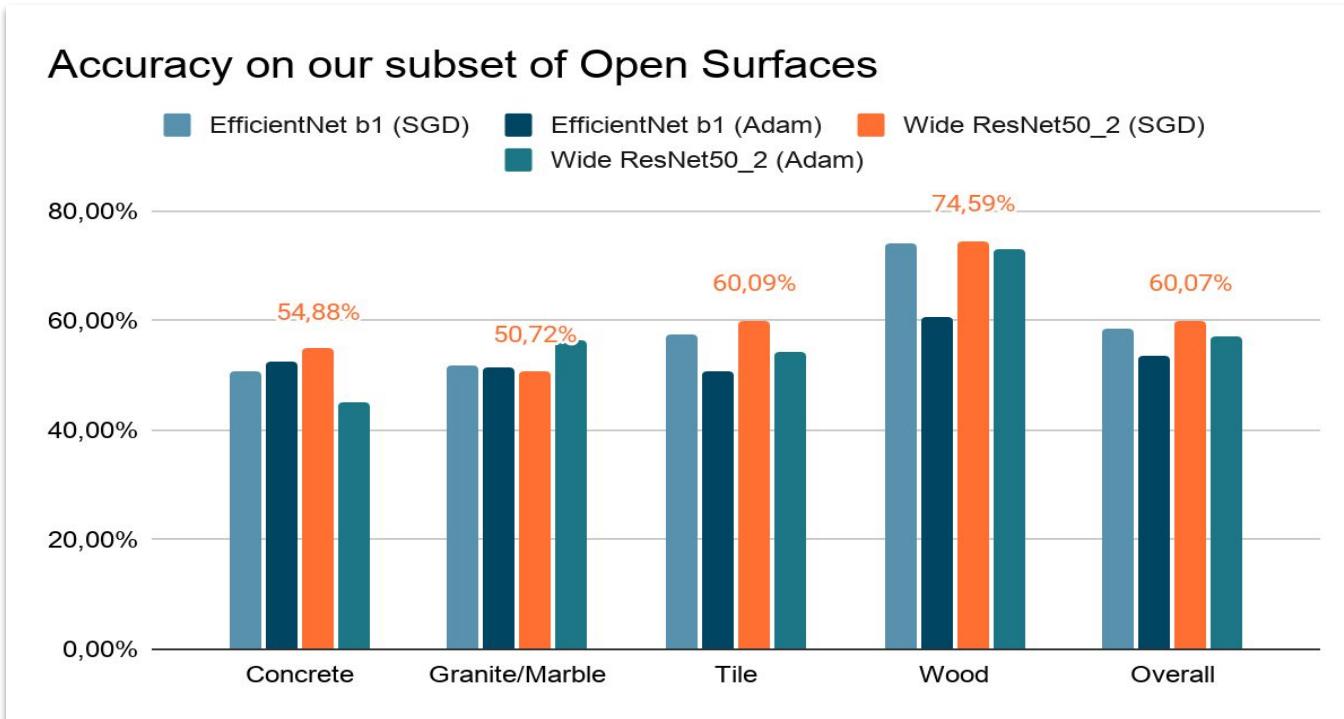


Datasets for Classification

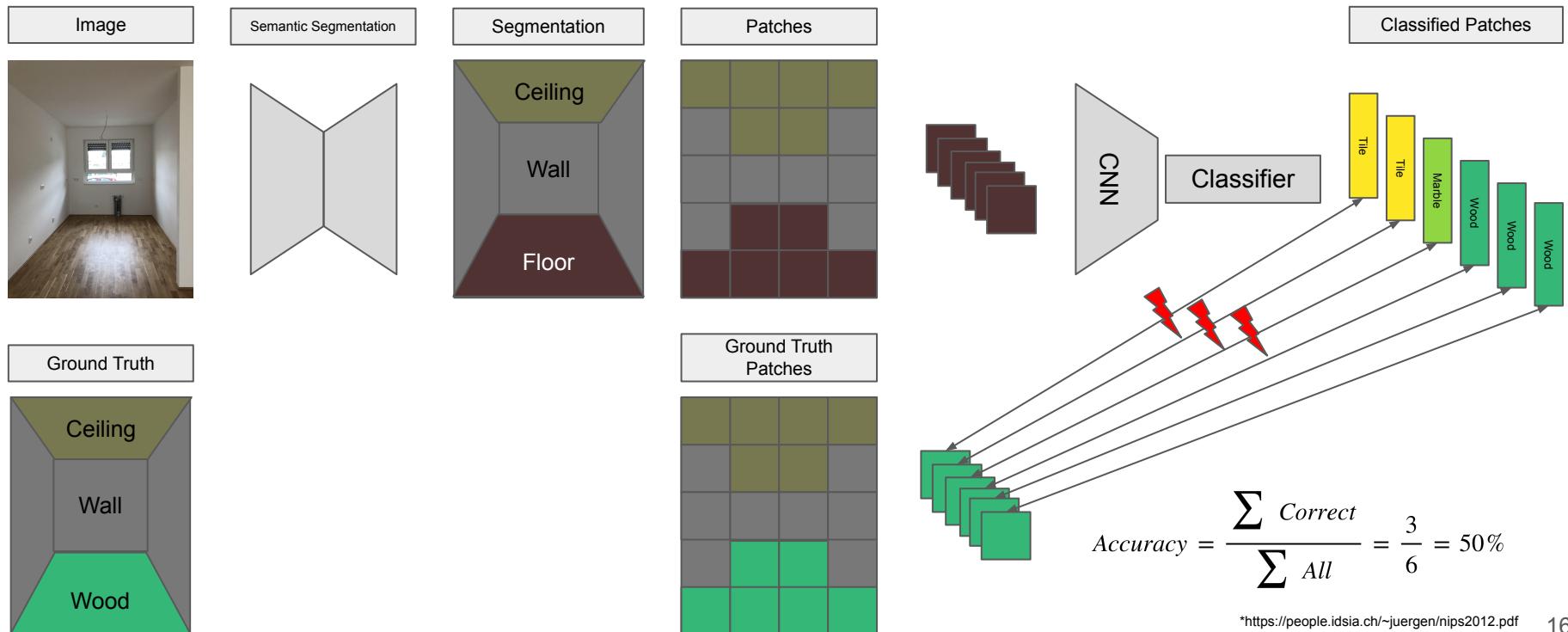
- Original Open Surfaces* dataset is very large (~115,000 images; ~3mb per image)
- Only used a subset:
 - Downloaded images and **cropped segments** from classes of interest
 - Sampled patches from every segment
 - Balanced number of patches over classes
- Our own dataset derived from Open Surfaces*:
 - Tested 32x32, 64x64 and 128x128
 - Used 128x128 cropped patch size
 - 5530 patches per class
 - 80/20 split train/eval



Material Classification - Training and Evaluation



Material Classification - Quantitative Results



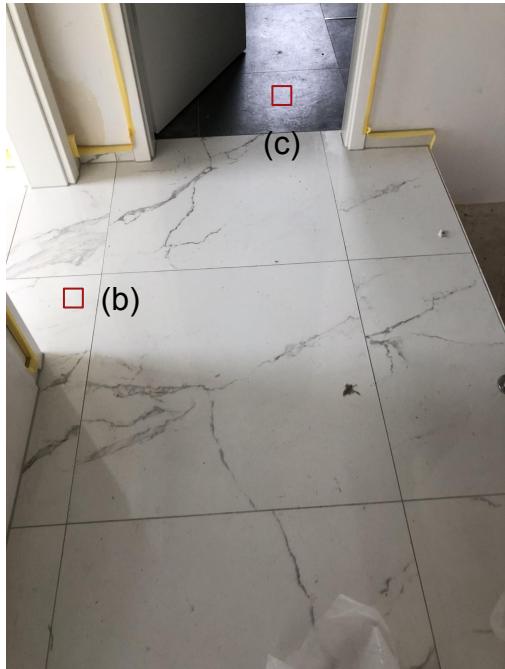
Material Classification - Quantitative Results

- EfficientNet & wide ResNet pretrained on ImageNet
 - finetuned on MINC2500 & our subset of Open Surfaces
- Used two different optimizers
- Tested with self annotated construction site images

	EfficientNet				Wide ResNet			
Dataset	MINC 2500	Open Surfaces 128x128	Open Surfaces 224x224	Open Surfaces flip 224x224	MINC 2500	Open Surfaces 128x128	Open Surfaces 224x224	Open Surfaces flip 224x224
Accuracy (SGD) (Patch)	32%	50,72% (44,87%)	47,7% (31,94%)	44,61% (49,58%)	52% (29,06%)	43,5% (41,88%)	50,7% (50,61%)	47,69% (50,72%)
Accuracy (Adam) (Patch)	39,1% (18,97%)	52,17 % (49,76%)	47,69% (47,65%)	52,31% (52,83%)	58% (31.53%)	42% (37,15%)	47,7% (52,25%)	49,23% (55,01%)

Image Segmentation - Qualitative Results

- Problems with patch classification in our project:



Can you guess which patch belongs to which material?

Options: concrete, marble, tile and wood

1



2



Conclusion

- Implemented a semantic segmentation and material classification pipeline
 - Compared two state-of-the-art semantic segmentation models
 - Deeplab V3+
 - HRNet V2
 - Trained different material classifiers (on MINC2500 & subset of Open Surfaces)
 - EfficientNet
 - Wide ResNet
 - Created two datasets ourself for training, evaluation and testing
 - Sampled patches with labels from a subset of OpenSurfaces
 - Built an own semantic segmentation dataset from construction site images
 - Trained and tested different classifiers with our composed datasets

Thank you for your attention