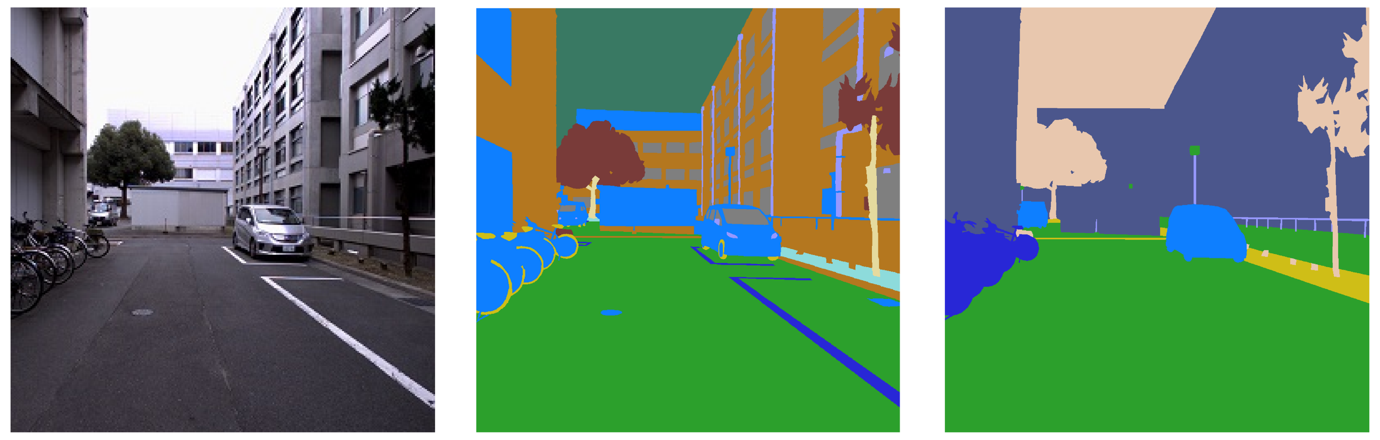
Beyond Appearances: Material Segmentation with Embedded Spectral Information from RGB-D imagery

Fabian Perez and Hoover Rueda-Chacón
Universidad Industrial de Santander, Departament of Computer Science

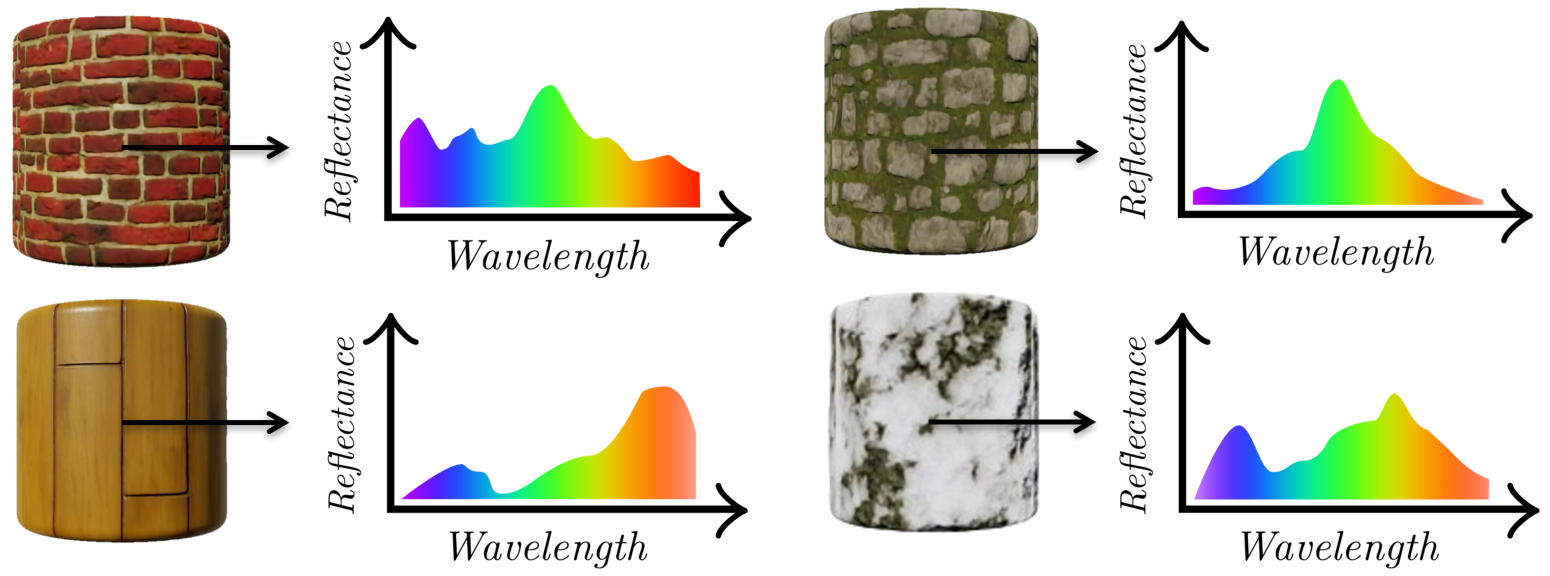
Introduction

Motivation: Image segmentation consists on classifying pixels into multiple homogeneous regions, with each region exhibiting similar properties. In particular, material segmentation seeks to classify these pixels based on the objects' material rather than in terms of the objects themselves, as it is the case in semantic segmentation.



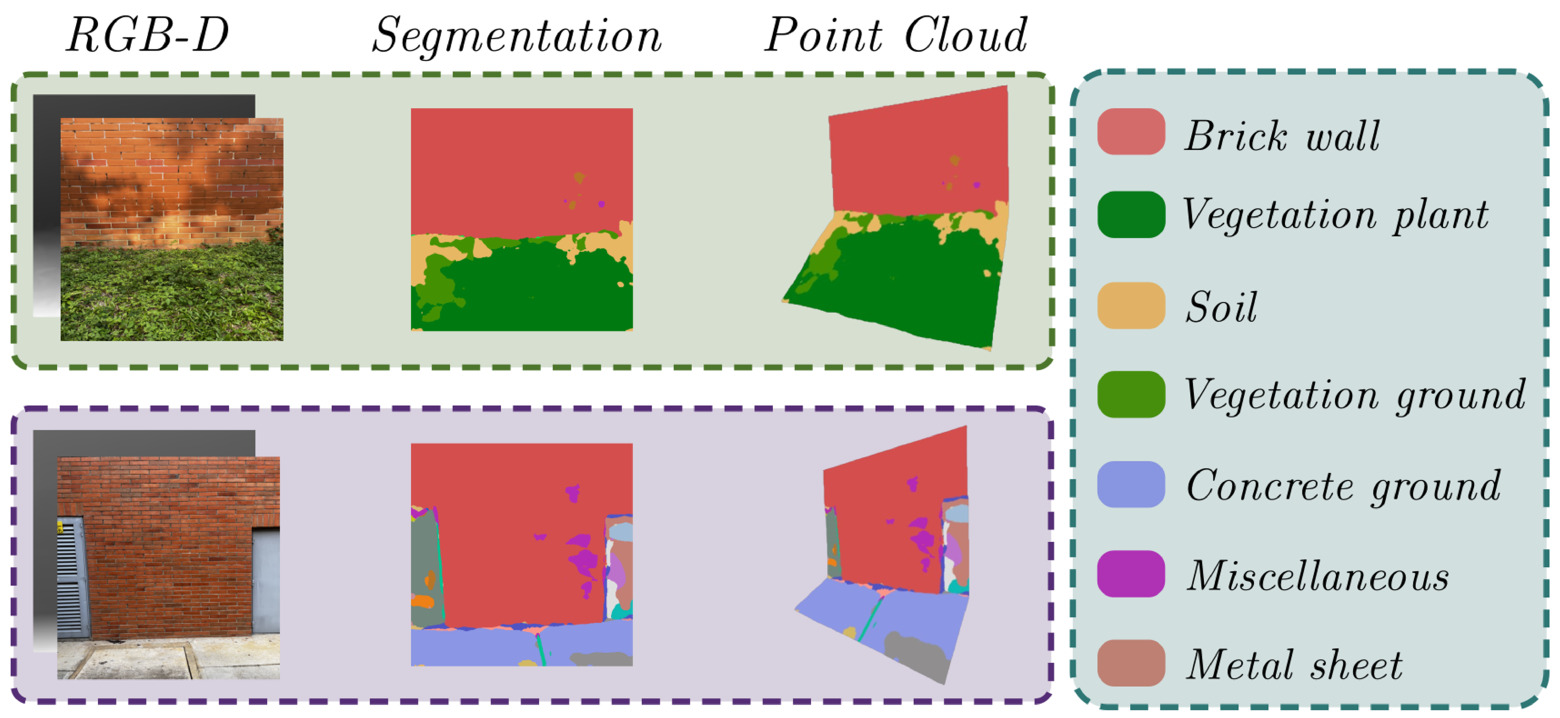
RGB   Materials   Semantics

Unlike semantic segmentation, material segmentation is more challenging since spectral reflectance signatures of objects are preferred over color information, for high reliability.

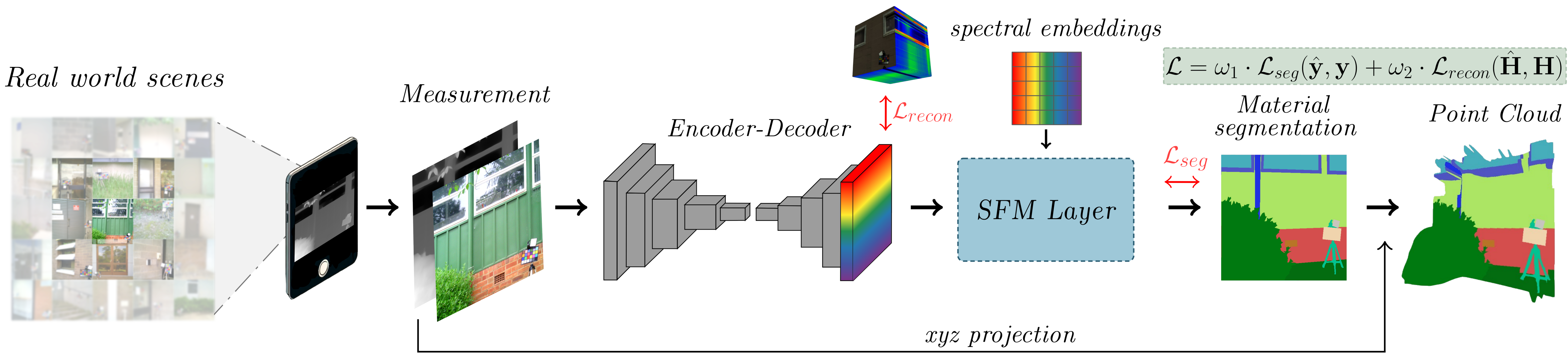


Experiments

We conducted experiments in an iPad Pro, leveraging its ability to capture high-quality RGB-D images



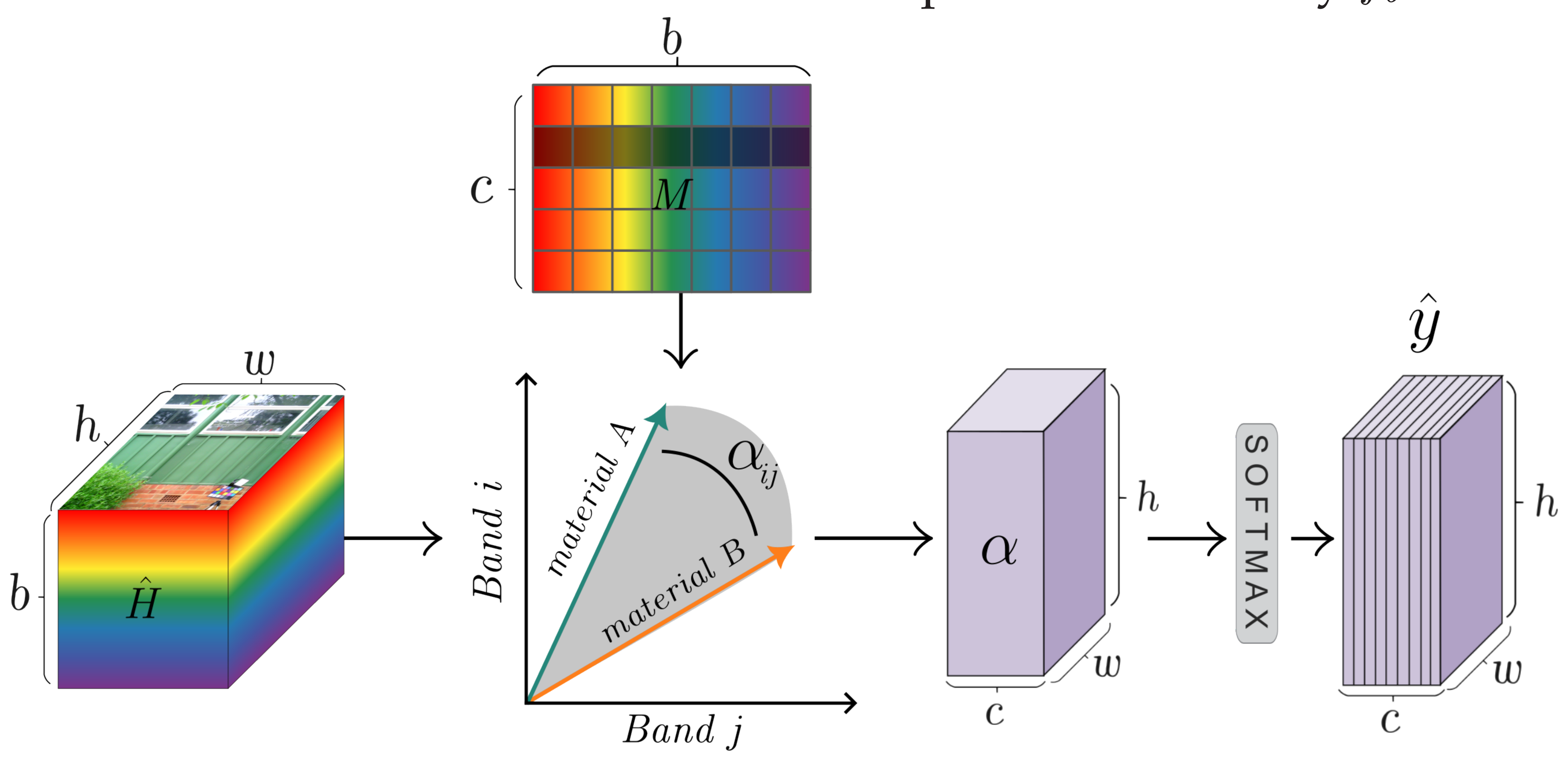
Proposed framework



Proposed framework utilizing the Spectral Feature Mapper (SFM). An off-the-shelf device captures an RGB-D image, which is then processed by an encoder-decoder network producing a hyperspectral reconstruction $\hat{\mathbf{H}}$. This reconstruction is operated on by the SFM layer using learned spectral embeddings to achieve material segmentation. Furthermore, a segmented point cloud is generated.

Spectral feature mapper (SFM)

We introduce the SFM layer, this layer is designed to universally enhance encoder-decoder architectures parameter-ized by f_θ



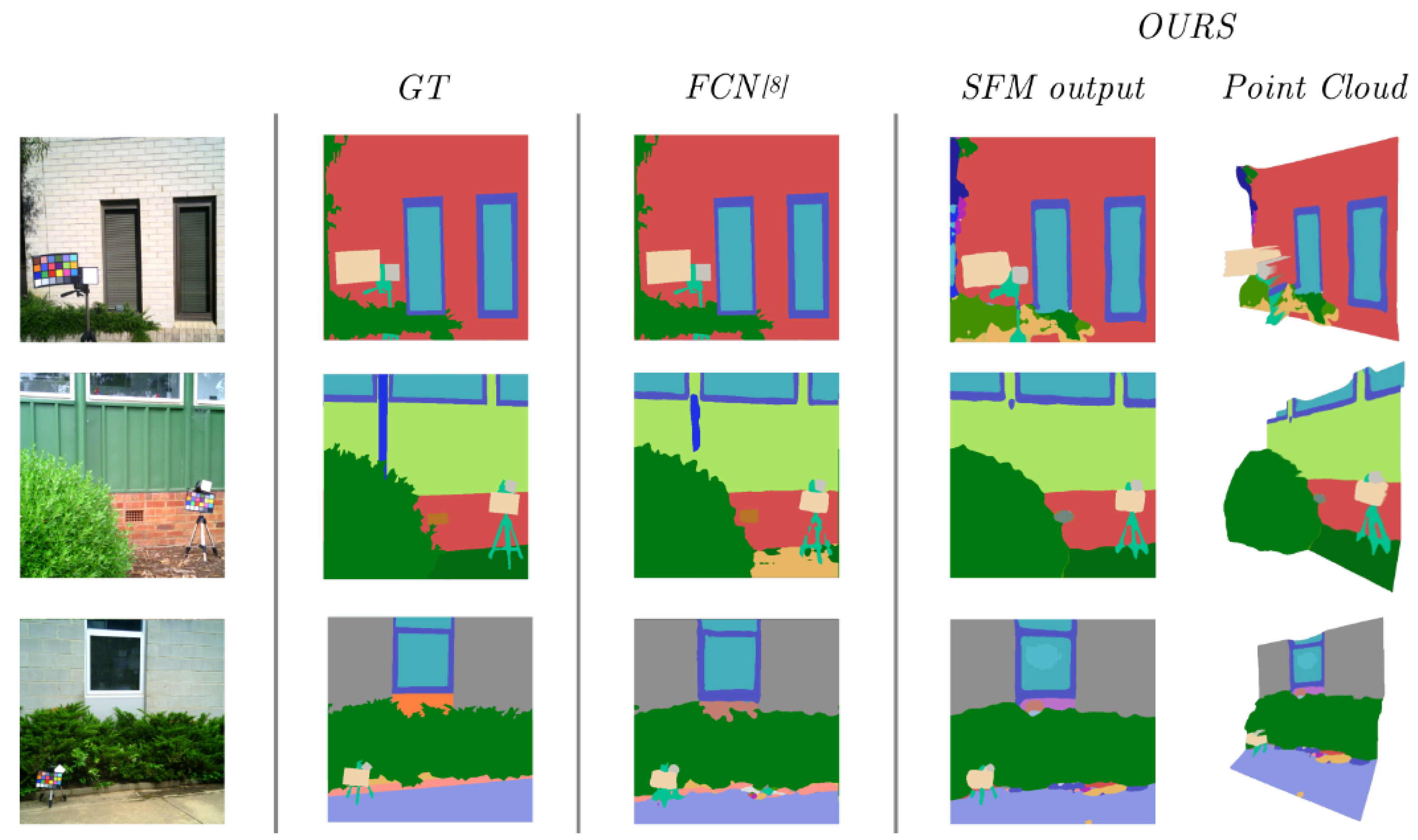
SFM works taking the negative of the spectral angle α between two matrices containing the spectral curves, $\hat{\mathbf{H}} \in \mathbb{R}^{h \times w \times b}$ (reconstructed spectrum) which is reshaped to $\bar{\hat{\mathbf{H}}} \in \mathbb{R}^{hw \times b}$ and $\mathbf{M} \in \mathbb{R}^{c \times b}$ (materials spectrum), as follows:

$$\alpha = -\cos^{-1}\left(\frac{\bar{\hat{\mathbf{H}}} \cdot \mathbf{M}^T}{\|\bar{\hat{\mathbf{H}}}\|\|\mathbf{M}\|}\right), \hat{\mathbf{y}} = \text{softmax}(\alpha)$$

Results

We evaluated the proposed framework on the publicly available Light Industrial Building HSI (LIB-HSI) dataset [11]

Input	Method	Accuracy	Average Class IoU
RGB	U-Net [11]	0.687	0.236
RGB	FCN [11]	0.829	0.443
RGB-D	Ours	**0.8647**	**0.4837**



Contact

Code https://github.com/factral/Spectral-Material-Segmentation/
Email nelson2200183@correo.uis.edu.co

References

[1] Yupeng Liang, Ryosuke Wakaki, Shohei Nobuhara, and Ko Nishino. Multimodal material segmentation. CVPR 2022
[2] Nariman Habili, et al. A hyperspectral and rgb dataset for building facade segmentation. ECCV 2022
[3] Paul Upchurch and Ransen Niu. A dense material segmentation dataset for indoor and outdoor scene parsing. ECCV 2022