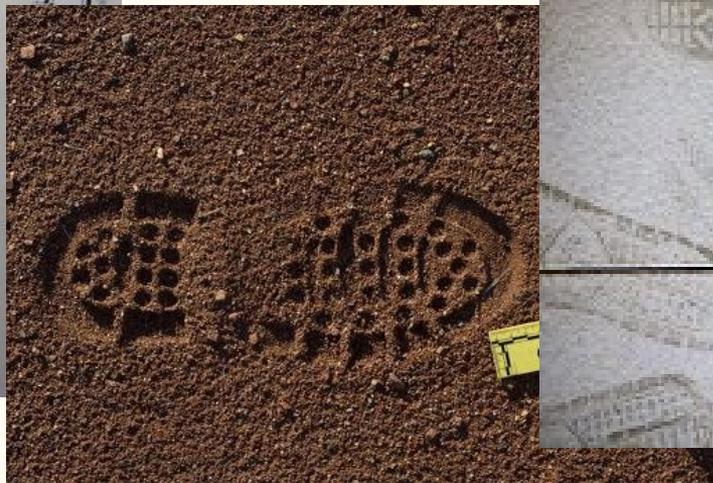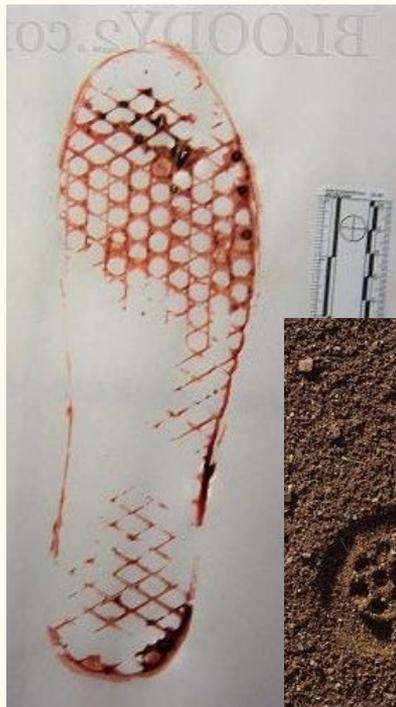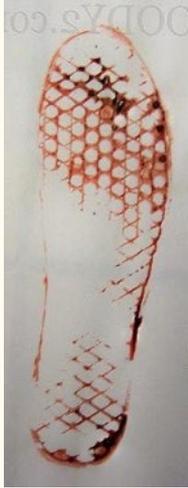# Predicting Shape, Reflectance and Impressions from Photos of Shoe Treads

—

Samia Shafique, Charless Fowlkes

# Crime Scene Shoe Prints

# Matching Print to Shoe



Crime Scene Print

Shoes

...

Which class of shoe left the print?

# Matching Print to Shoe



Crime Scene Print

Lab Impressions

Shoes

Previous work
- Cross-Domain Image Matching with Deep Feature Maps, IJCV 2018

Improvements
- Complete set of shoes
    - New shoes every month
- Automatic print generation

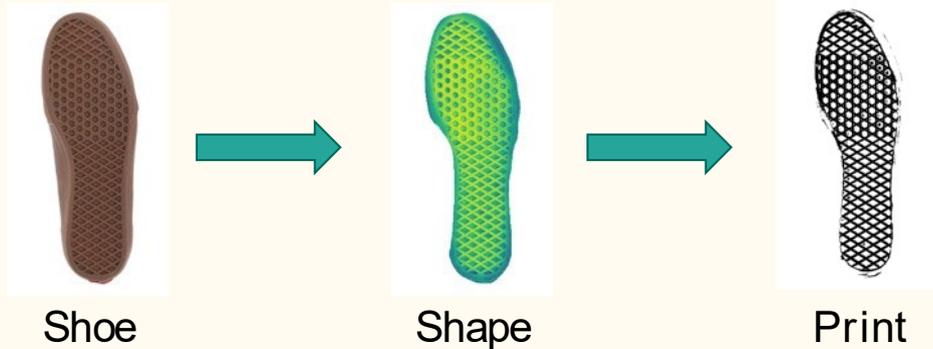# Shoe Tread Images from Online Retailers



Constant stream of data from online retailers

How can we use this?

Photos of Shoe Treads from Online Retailers
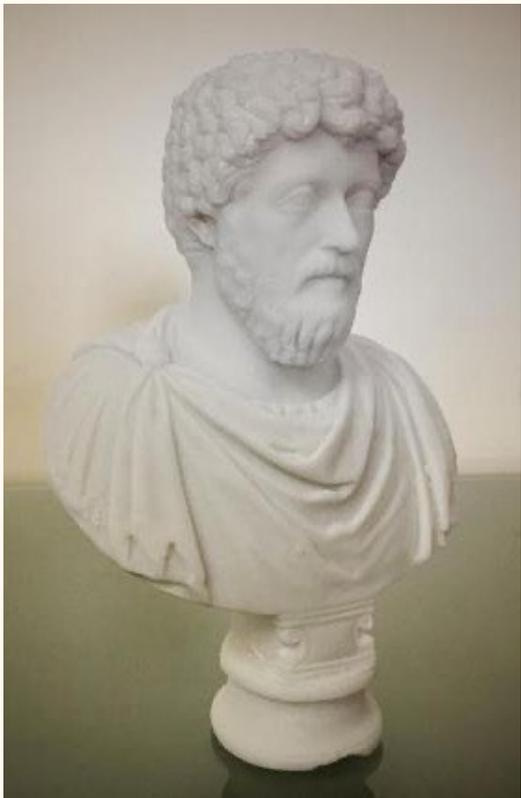
# Dataset of Shoe and Corresponding Print



Shoe → Shape → Print

- Learn shape and print from shoe tread images

- Create one to one mapping of shoes and prints using online retailer images

# Related Work

# Shape From Shading (SFS)



- Strong assumptions

  a. Known point light source

  b. Lambertian surface

  c. Known reflectance

# Inverse Rendering

1. Infer shape, color and lighting from images

2. Ill posed problem

3. Retinex model (Land 1967)

   - Smooth variation in lighting

   - Sharp transitions in color

1. Learning based approaches can utilize statistics of data distribution to disambiguate the problem
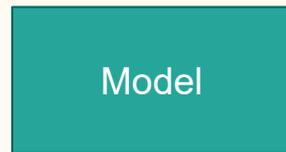
# Machine Learning

- Regression model - given input X, predict output Y

- Train the model using
    - Example $(X_i, Y_i)$ pairs
        - Model learns to predict output for other similar input
    - Loss function
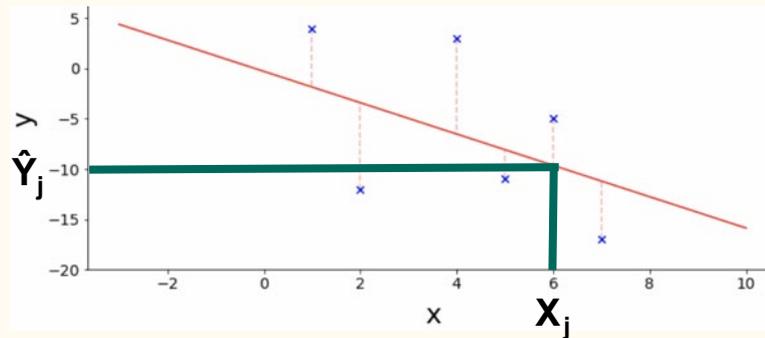        - Measure of how well the ground truth $(Y_i)$ matches model output prediction $(\hat{Y}_i = f(X_i))$
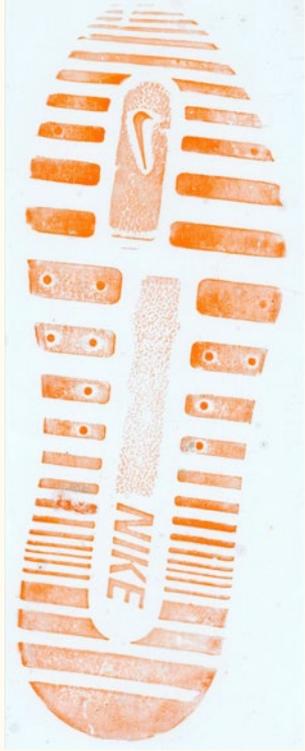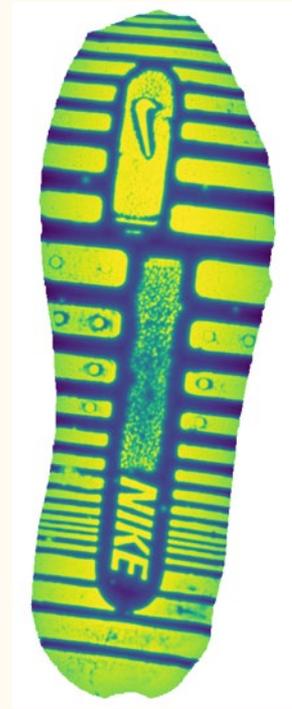
Color

Model

Shape

Shoe

Light

$\hat{Y}_j$

$X_j$

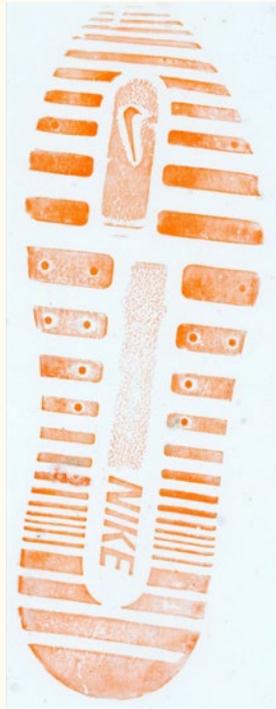# Synthetic Data Generation

Shoe prints

# Generating Depth Maps

# Generating Color Maps



Shape from
depth map

$+$

Color scheme from
online shoes

$\rightarrow$

Color map

# Rendering Shoes



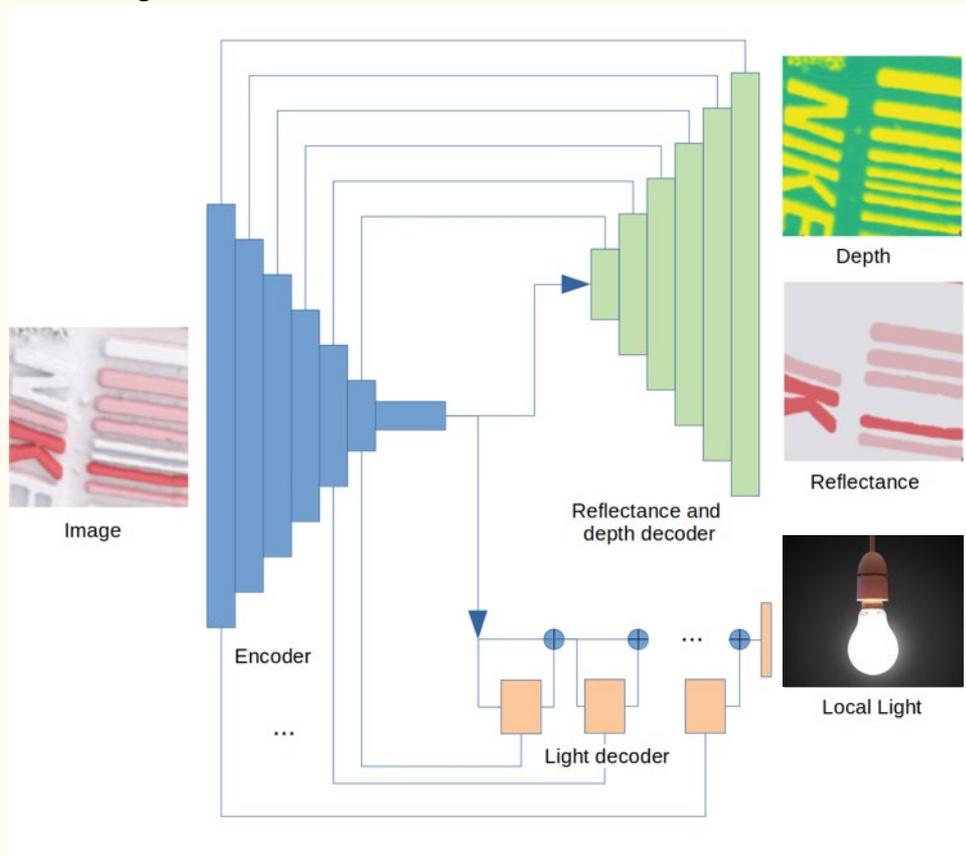Color map              Depth map              Light environment              Rendered Image
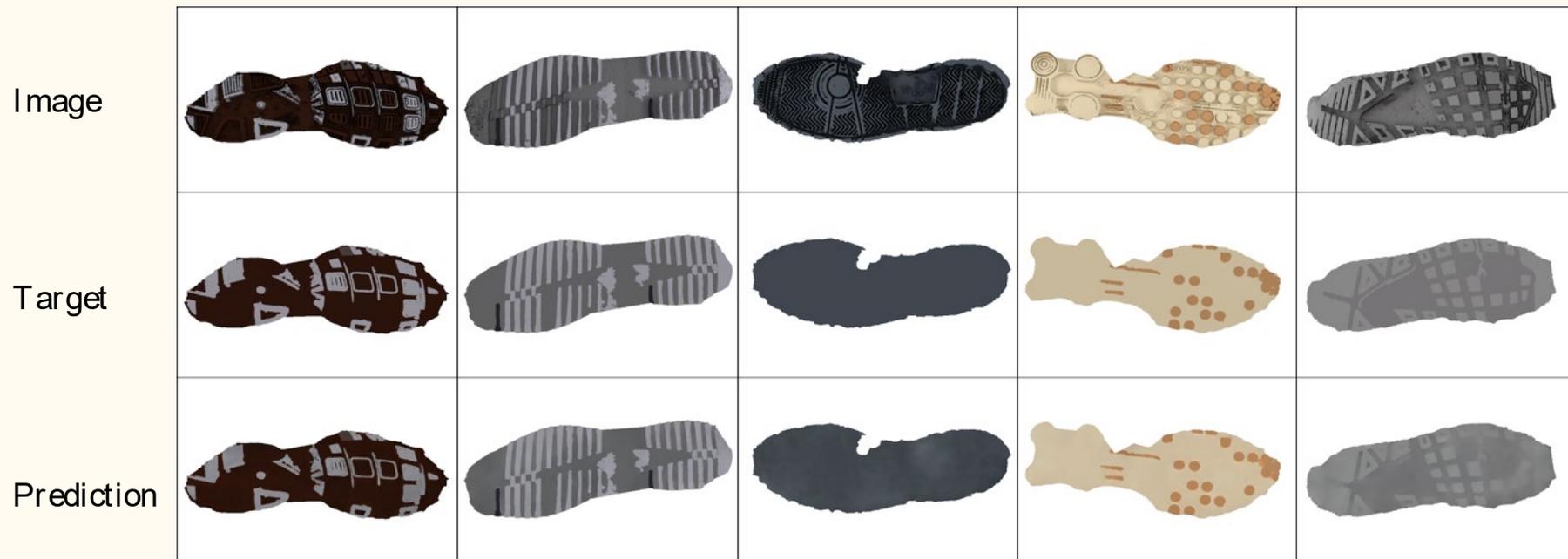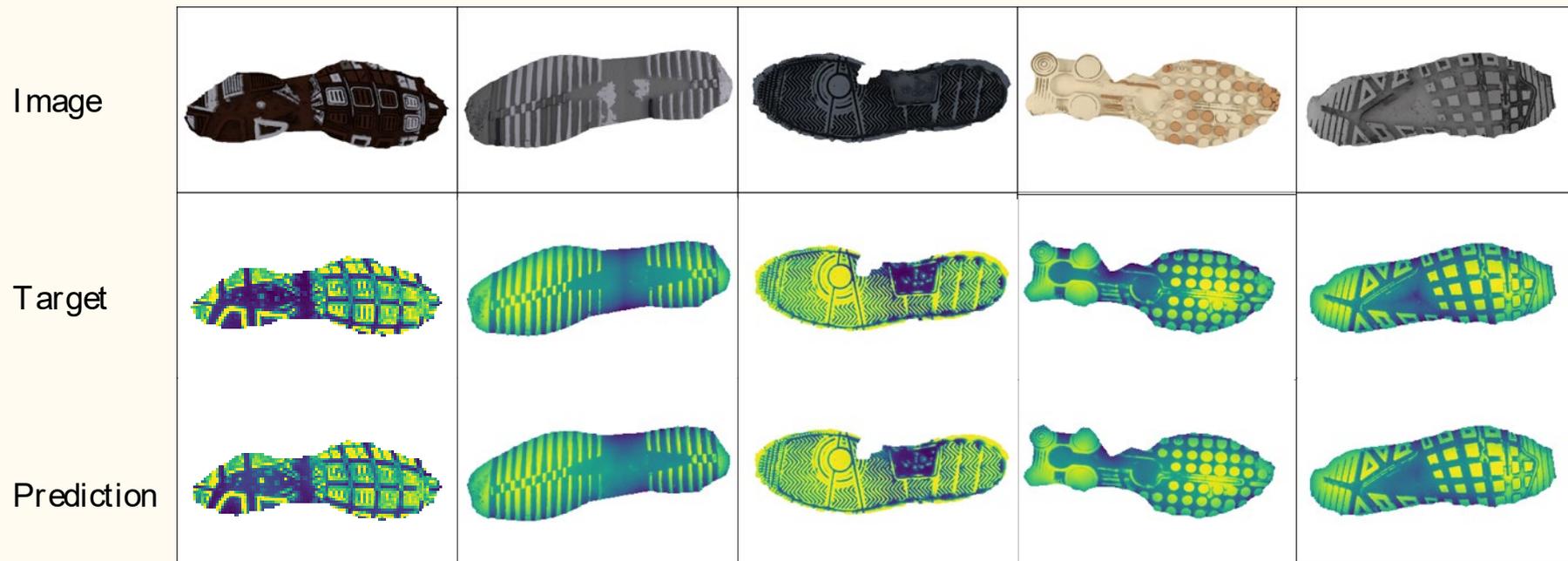
# Rendering Shoes

# Training Model

# Training on Synthetic Shoes

# Results on Synthetic Shoes - Color

# Results on Synthetic Shoes - Depth

# Training on Real Shoes



Image

Encoder

...

Light decoder

Reflectance and depth decoder

Depth

Reflectance

Local Light
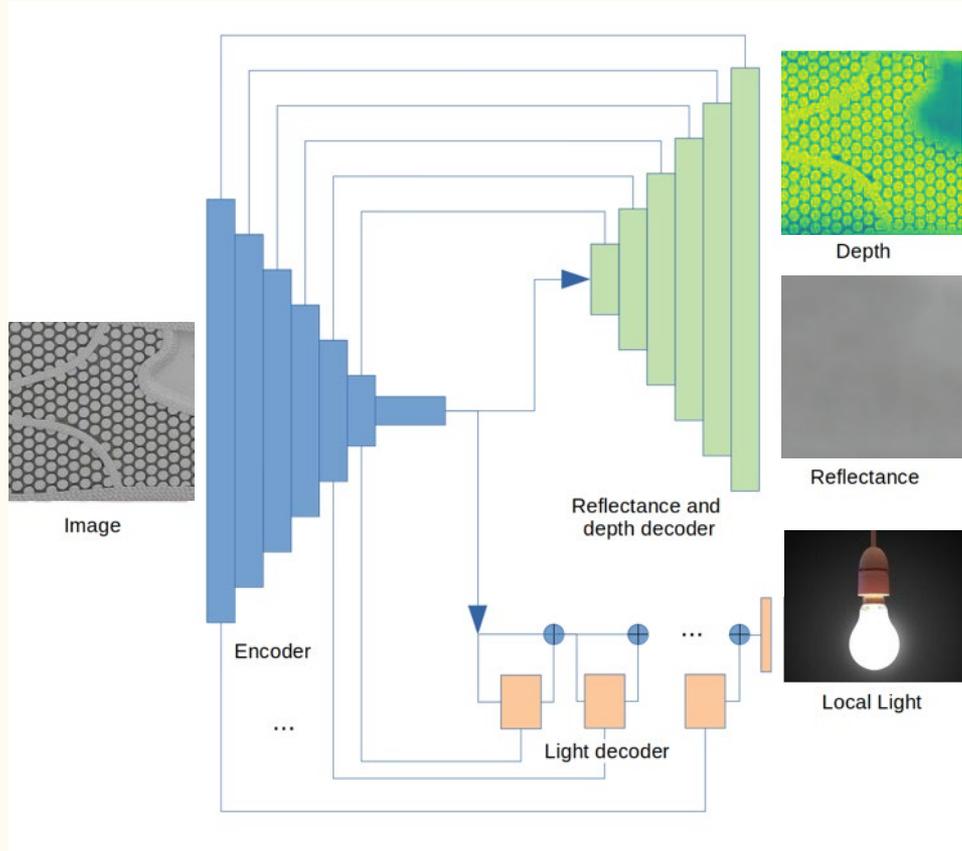


Estimating color of real shoes using a variant of Mean Shift algorithm

# Training on Real Shoes



Image

Encoder

...

Light decoder

Reflectance and depth decoder

Depth

Reflectance

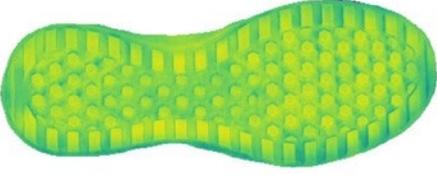Local Light

Differentiable renderer
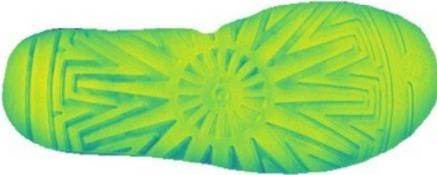
Image Reconstruction
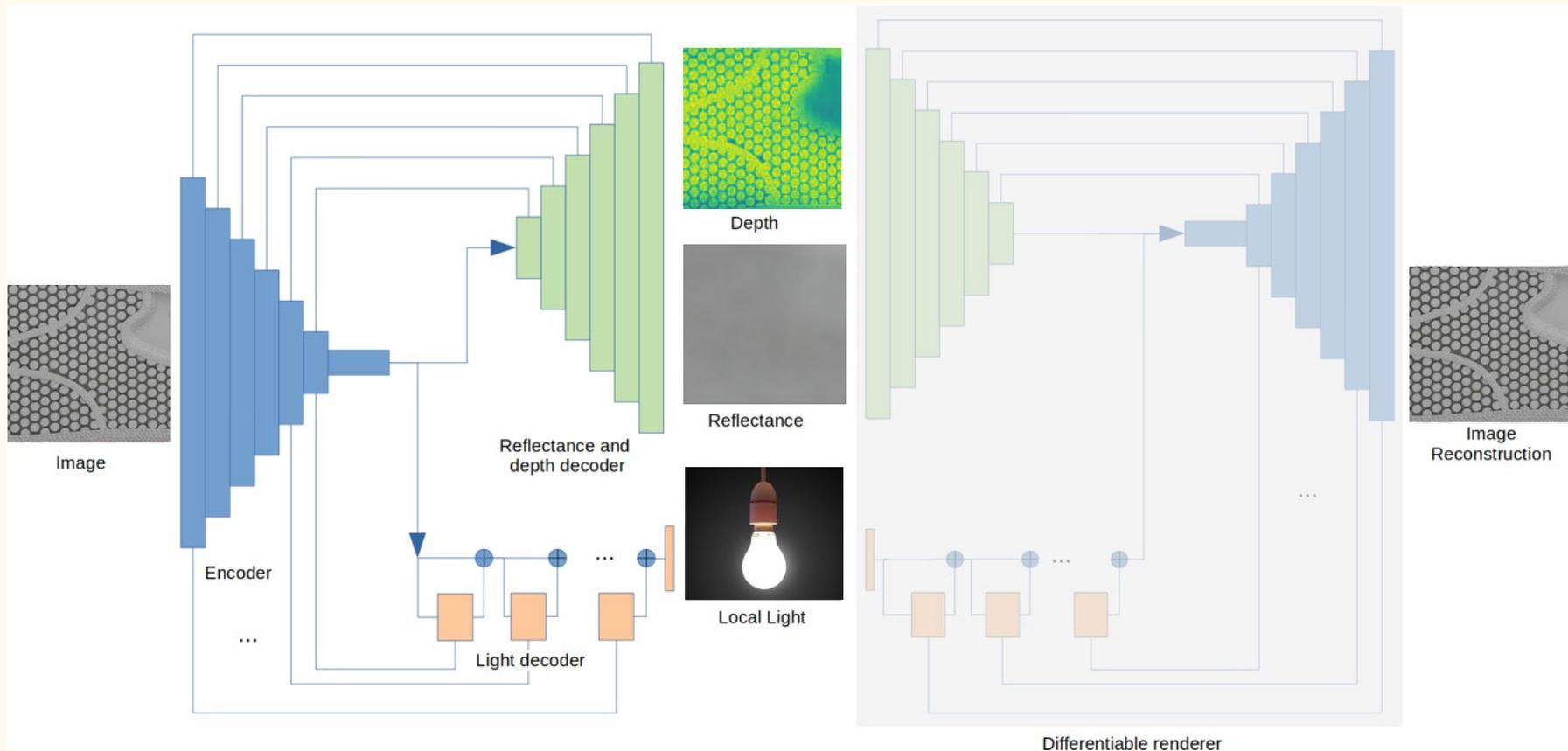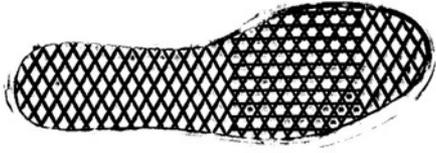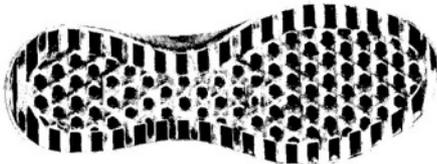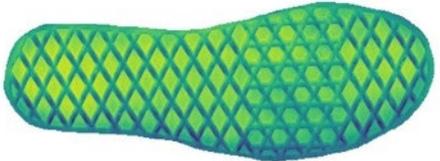
# Results on Real Shoes

# Results on real shoes

Shoe tread image

Depth map prediction

Our print prediction

# Results on real shoes



Shoe tread image

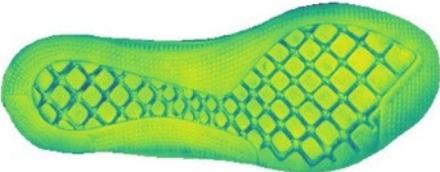Depth map prediction
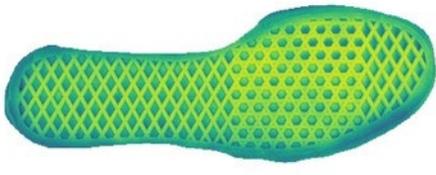
Our print prediction
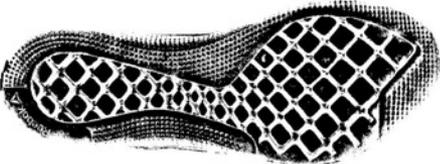
# Results on real shoes

Shoe tread image

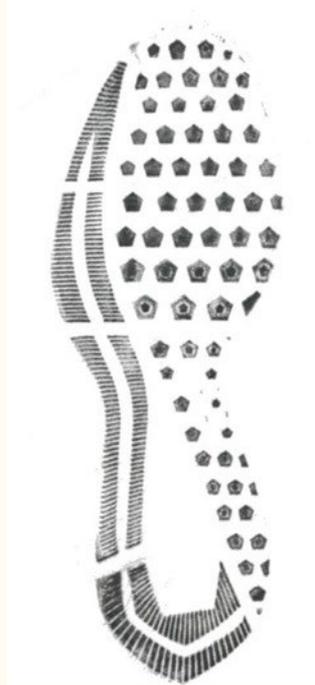Depth map prediction
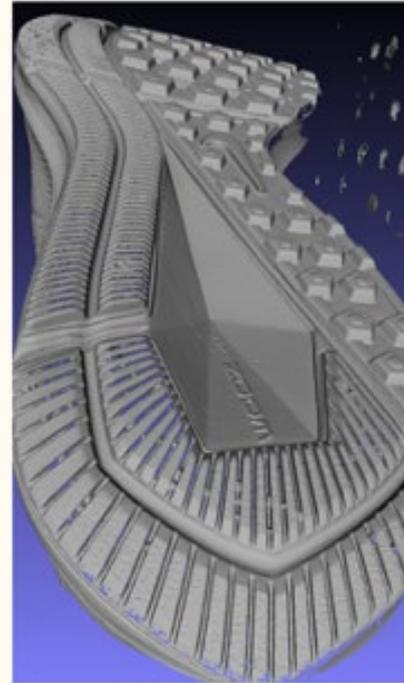
Our print prediction

# Ongoing Work

# Collecting Lab Impressions and 3D Scans



Shoe sole image　　　　　Lab Impression　　　　　3D shape

# Conclusion

- Predict impressions from photos of shoe treads

- Leverage the online retail images

- Match crime scene prints to real shoes sold online

Thank You!