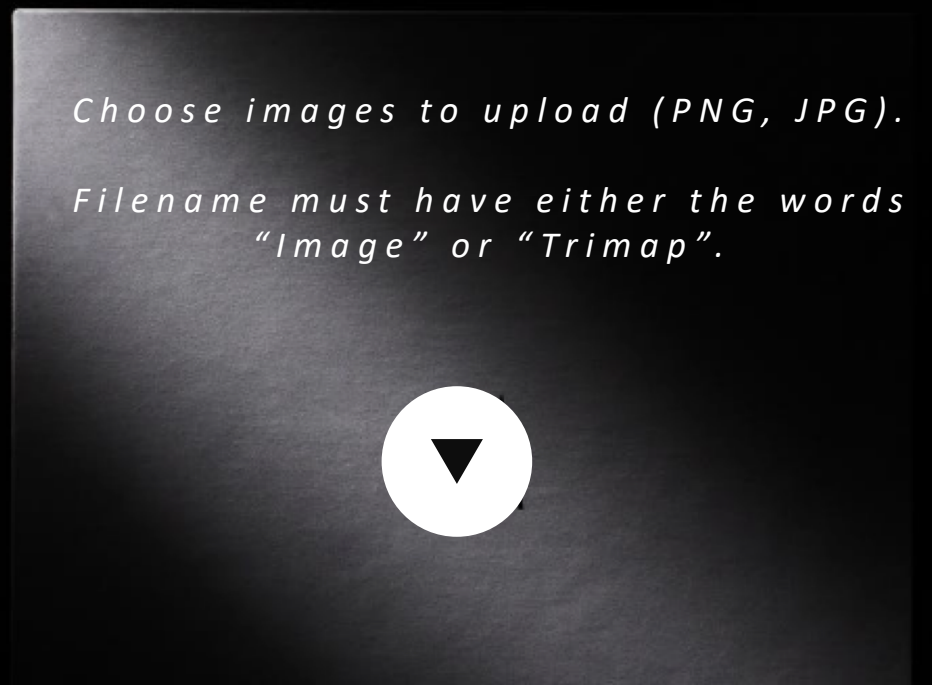
WE ARE DEEPMASQUE

We Create Real Masks

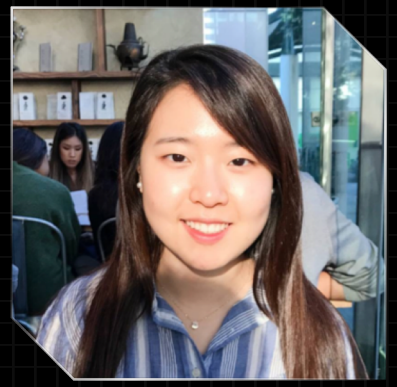


TEAM DEEPMASQUE

Interdisciplinary team of data scientists

Data Scientist
Yu-Chieh Lee

- Bachelor of Sci. in EECS
- Incoming Software Engineer at LinkedIn

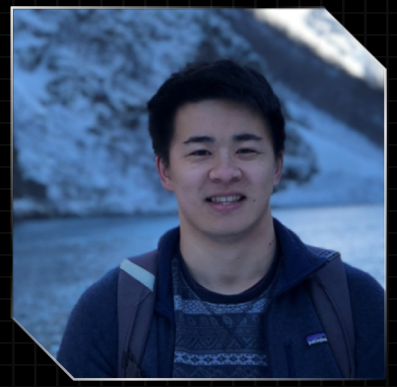


Data Scientist
Sierra Park

- Bachelor of Art in Applied Math
- Incoming Data Analyst at Wayfair

Data Scientist
Leo Li

- Bachelor of Art in Cognitive Science
- Bachelor of Art in Statistics



Data Scientist
Chris Chin

- Bachelor of Sci. in Civil Engineering
- Incoming Researcher at MIT

THE GREEN SCREEN TECHNIQUE

A ubiquitous post-production technique

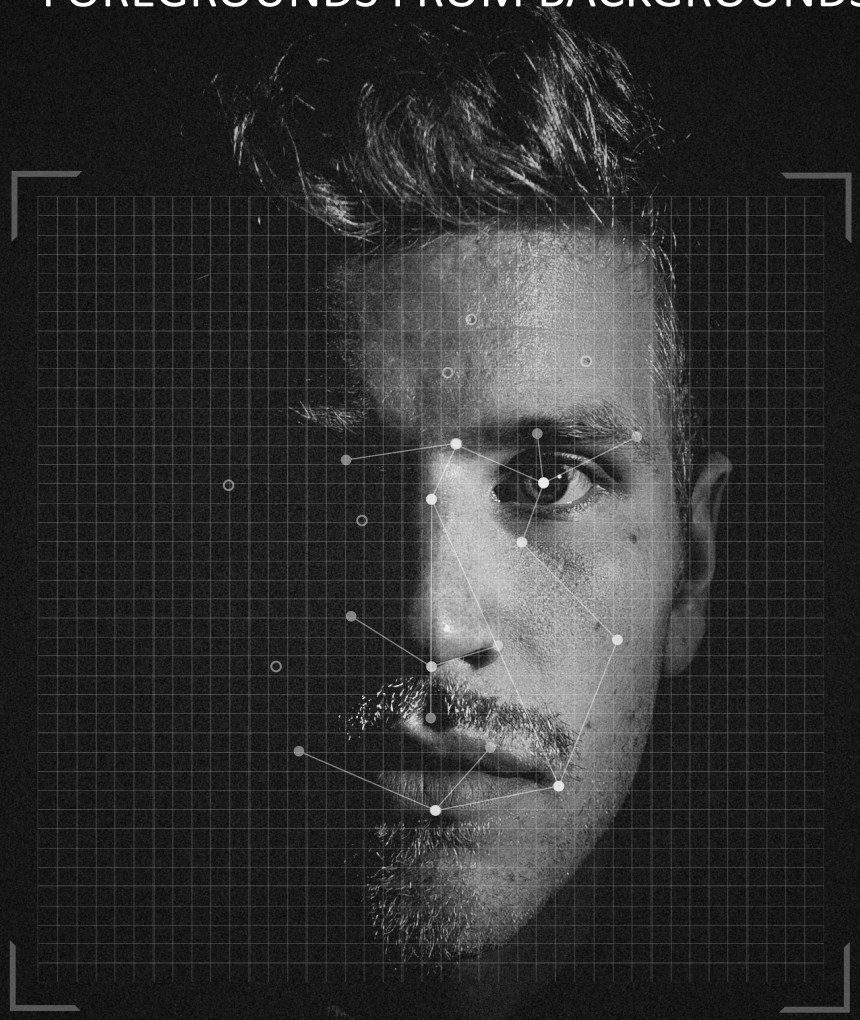
- A green screen is a uniform backdrop used in filming, 3-D printing, and VR
- Allows editors to easily separate the subject from the background to change the background
- Used by everyone from amateur film-ers to Hollywood producers

PROBLEMS

EXPENSIVE,
TIME-CONSUMING,
HIGH BARRIER FOR ENTRY

- Green screen film has to be processed by an editor
- Editing film is expensive, time-consuming, and difficult for beginners
- Is there a better way?

WE CREATE ACCURATE MASKS TO DIFFERENTIATE FOREGROUNDS FROM BACKGROUNDS



++++++

+

FACE

Our mission is to automate the editing process of photos in VR, AR, and entertainment, etc., through precise segmentation via deep learning.

Advisor

Richard Berwick

Richard@twindom.com

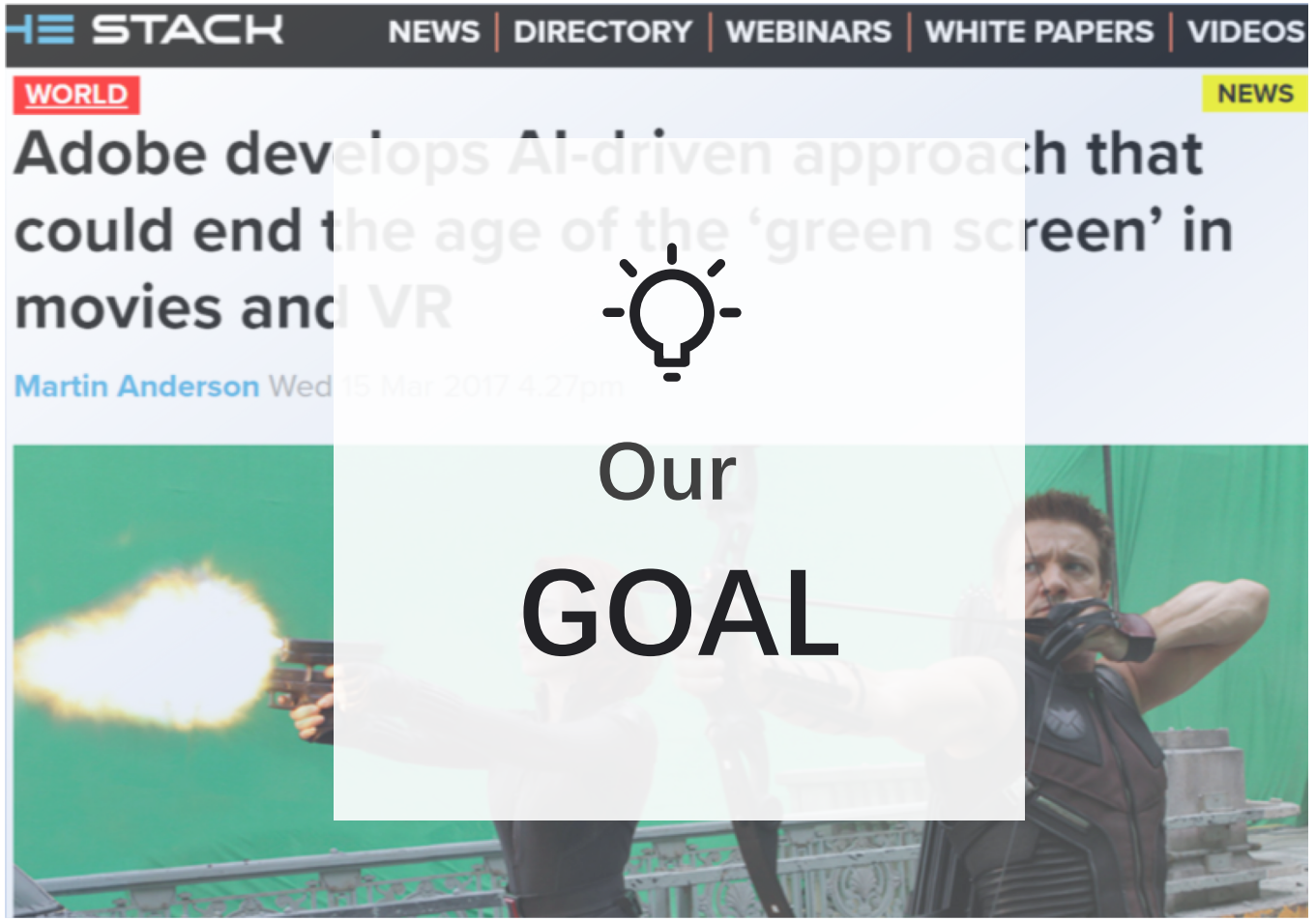
Image, Trimap, Alpha Matte
Portrait FCN+, KNN-Matting
Twindom
>>>>>>>>>>>>>>>>>>>>>>>

2018/5/2
Product Demo

www.deepmasque.com

ELIMINATE the need for a middle-man

- Make website where users can upload a portrait and instantly separate subject and background
- Enable users to change the background
- Film-makers of any calibre can circumvent the green screen process



OUR ALGORITHM vs MARKET COMPETITORS

Images from one-click background removal websites

01 INPUT IMAGE

02 OUR SEGMENTED IMAGE

03 BURNER.BON-ANZA.COM

04 MALABI.CO

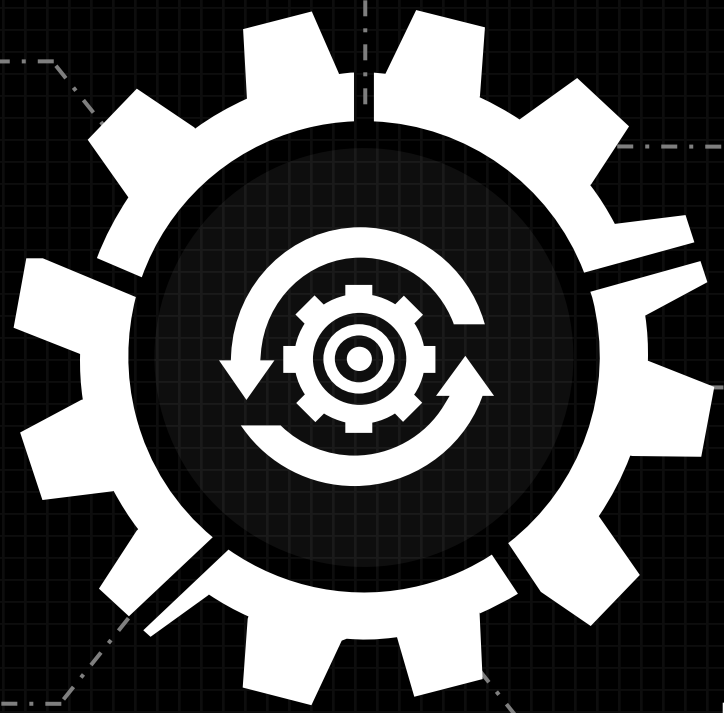
SOLUTION ARCHITECTURE

Pre-processing

- Take in RGB and find facial points by finding offset of x and y components to transform the picture to canonical pose.
- Apply mean mask transform to the image

Portrait FCN+

- Apply VGG on images using multiple smaller convolutional layers/filters for faster computation to capture nonlinearity
- Deconvolution to enlarge the small image back to its original size



Alpha Matte

ResNet

Training deep networks by finding the true y-values by predicting the error from the predicted y-values

Trimap

KNN Matting

User uses K nearest neighbors to get closed-form solution

SOLUTION ARCHITECTURE

Input

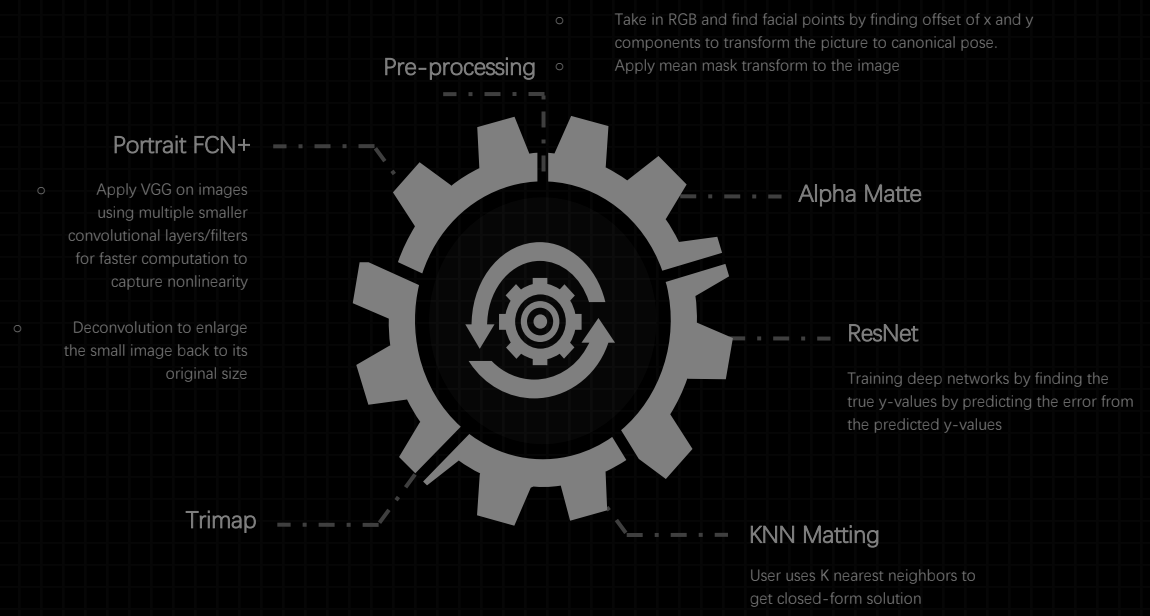
Input image of a person

SERVER 00

Amazon EC2 Server

Output

Foreground & Background Segmented



OVERVIEW OF SOLUTION

Making the complex seamless

01

INPUT IMAGE

02

TRIMAP

03

ALPHA MATTE

04

COMPOSITE IMAGE

Portrait FCN+

(in TensorFlow)

KNN Matting

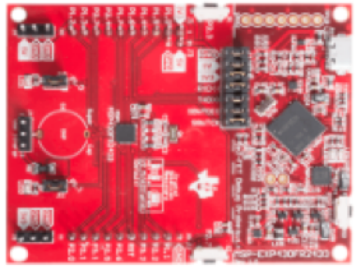
& Residual Network

Applying foreground on

another image

A tremendous memory demand reduction compared to state of the art

HARDWARE RESULTS & DEMAND



MSP-EXP430FR2433

Low cost MSP430 Value Line FRAM MCU LaunchPad.

Featuring the MSP430FR2433: 16-bit MCU with 16KB FRAM, 4KB SRAM and 10-bit 200KSPS ADC.

20-pin LaunchPad kit standard leveraging the BoosterPack ecosystem.

2 buttons and 2 LEDs for user interaction.

Capacity: 4 KB

Space Gray

Capacity: 64-256GB

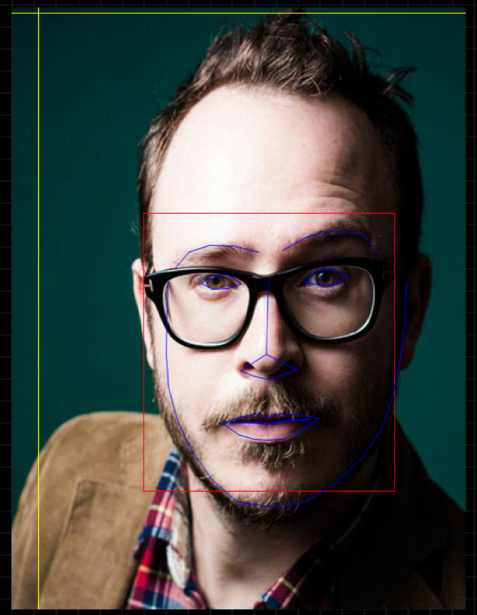
Reduced memory demand by over 2 GB (>> 2 times) with the elimination of DIM acting as middleman between trimap and alpha matte.

FYI: KB = 10^3, GB = 10^9

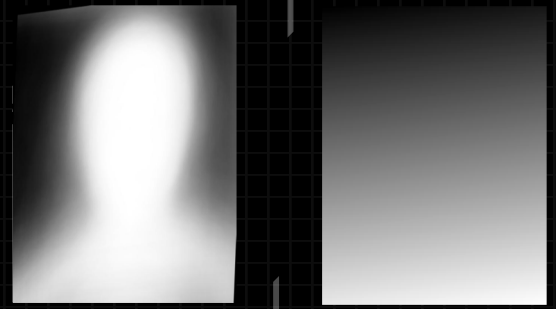
In fact, our trimap to alpha matte algorithm works particularly well due to PortraitFCN+ extreme accuracy in trimap generation and can be implemented on a LaunchPad.

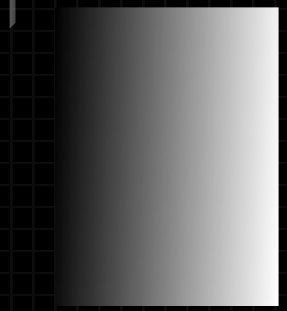
PORTRAIT FCN+: PREPROCESSING

01 INPUT IMAGE



02 DEEP METRIC LEARNING: FACIAL FEATURIZATION

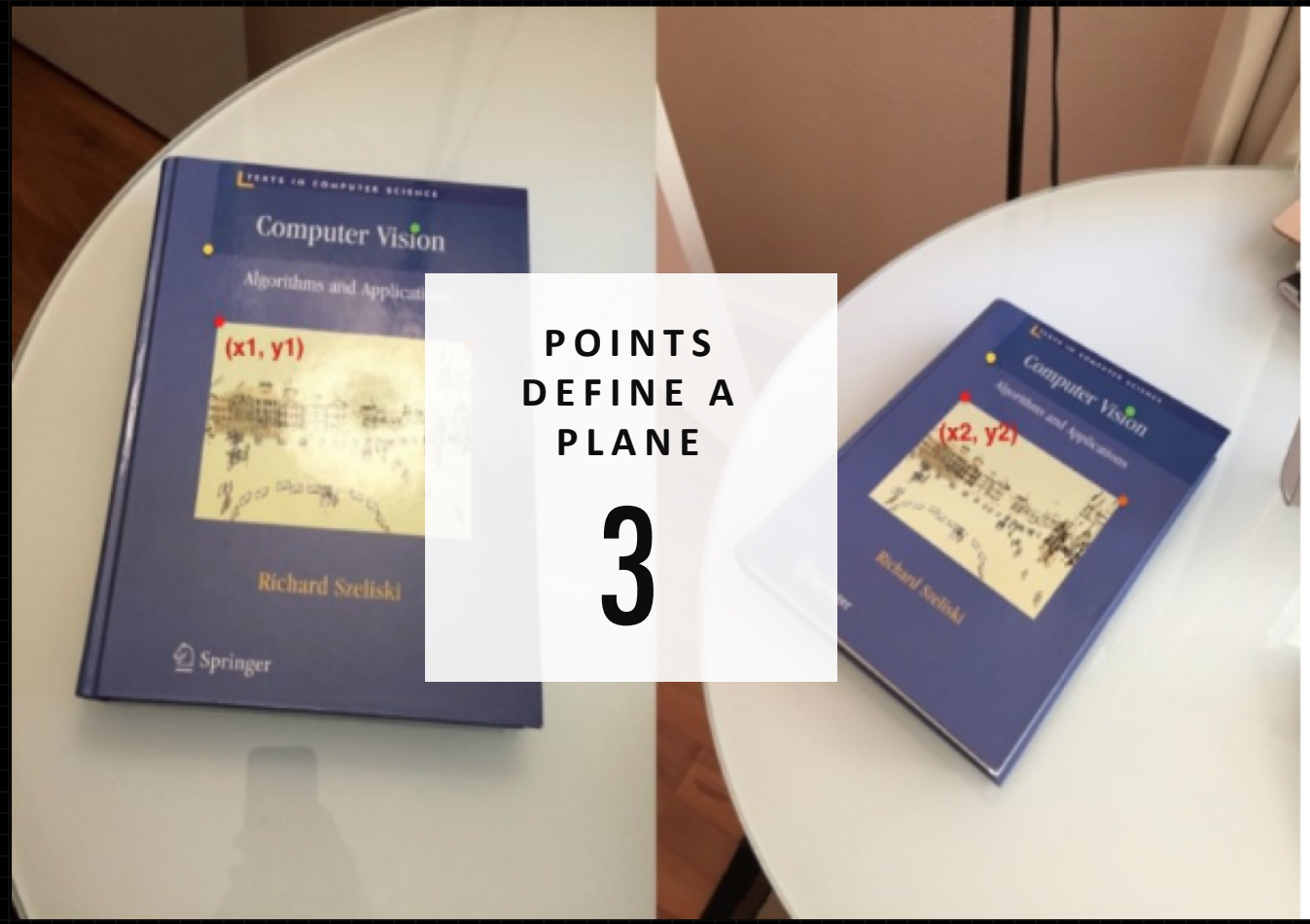




03 MEAN MASK ; YYC; XXC

04 REFERENCE IMAGE

PORTRAIT FCN+: PREPROCESSING

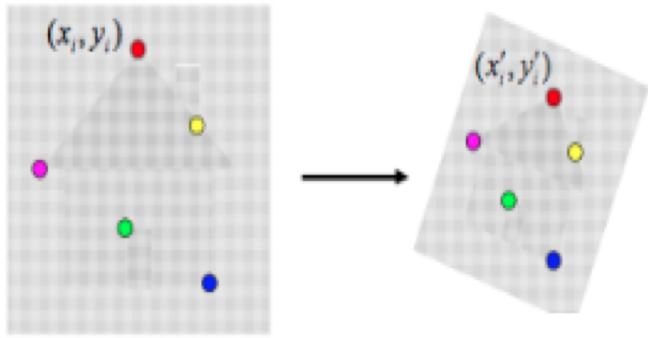


POINTS DEFINE A PLANE

3

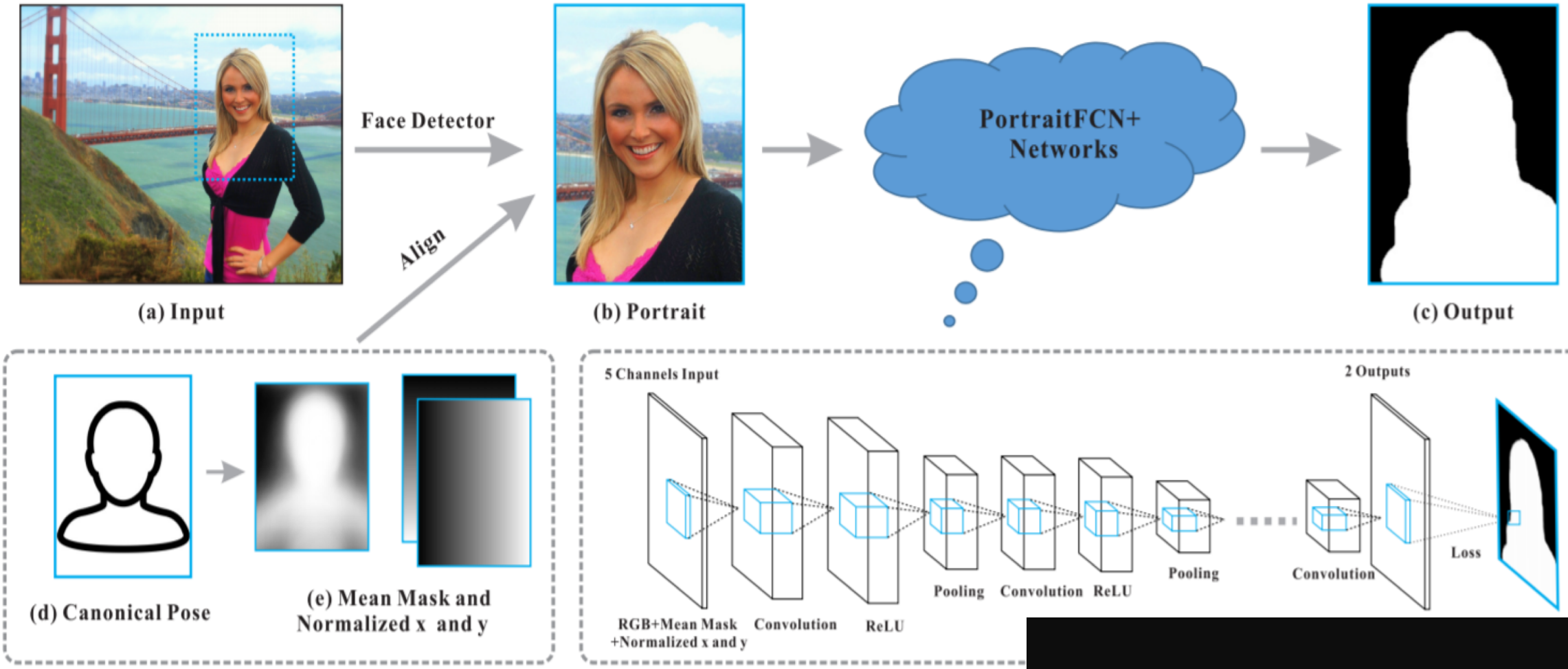
Fitting an affine transformation

- Assuming we know the correspondences, how do we get the transformation?



$$\begin{bmatrix} x_i' \\ y_i' \end{bmatrix} = \begin{bmatrix} m_1 & m_2 \\ m_3 & m_4 \end{bmatrix} \begin{bmatrix} x_i \\ y_i \end{bmatrix} + \begin{bmatrix} t_1 \\ t_2 \end{bmatrix}$$

$$\begin{bmatrix} \cdots & & & & & \\ x_i & y_i & 0 & 0 & 1 & 0 \\ 0 & 0 & x_i & y_i & 0 & 1 \\ \cdots & & & & & \end{bmatrix} \begin{bmatrix} m_1 \\ m_2 \\ m_3 \\ m_4 \\ t_1 \\ t_2 \end{bmatrix} = \begin{bmatrix} \cdots \\ x_i' \\ y_i' \\ \cdots \end{bmatrix}$$



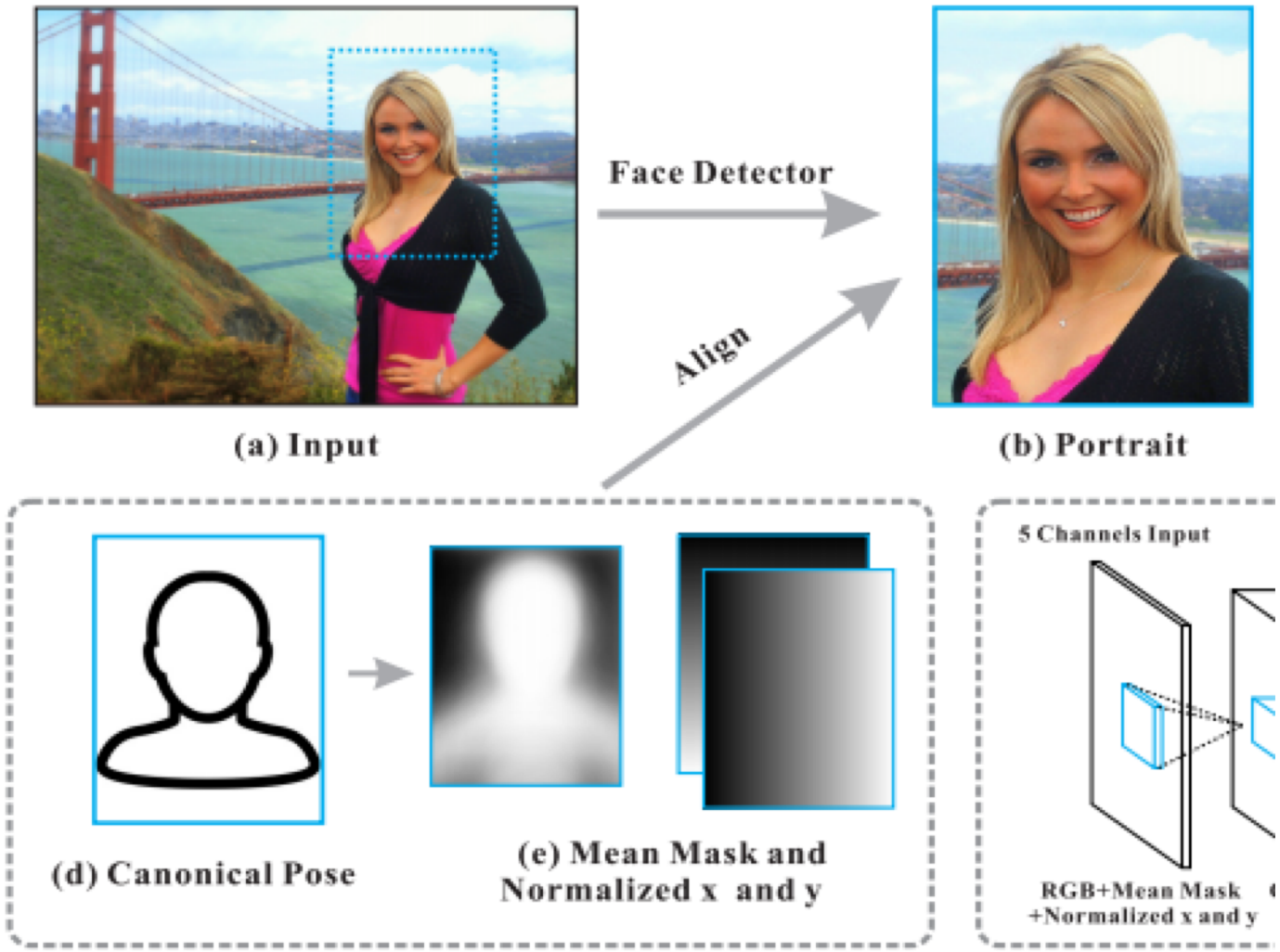
PORTRAIT FCN+

From Input to Trimap

PORTRAIT FCN+

Portrait-specific channels

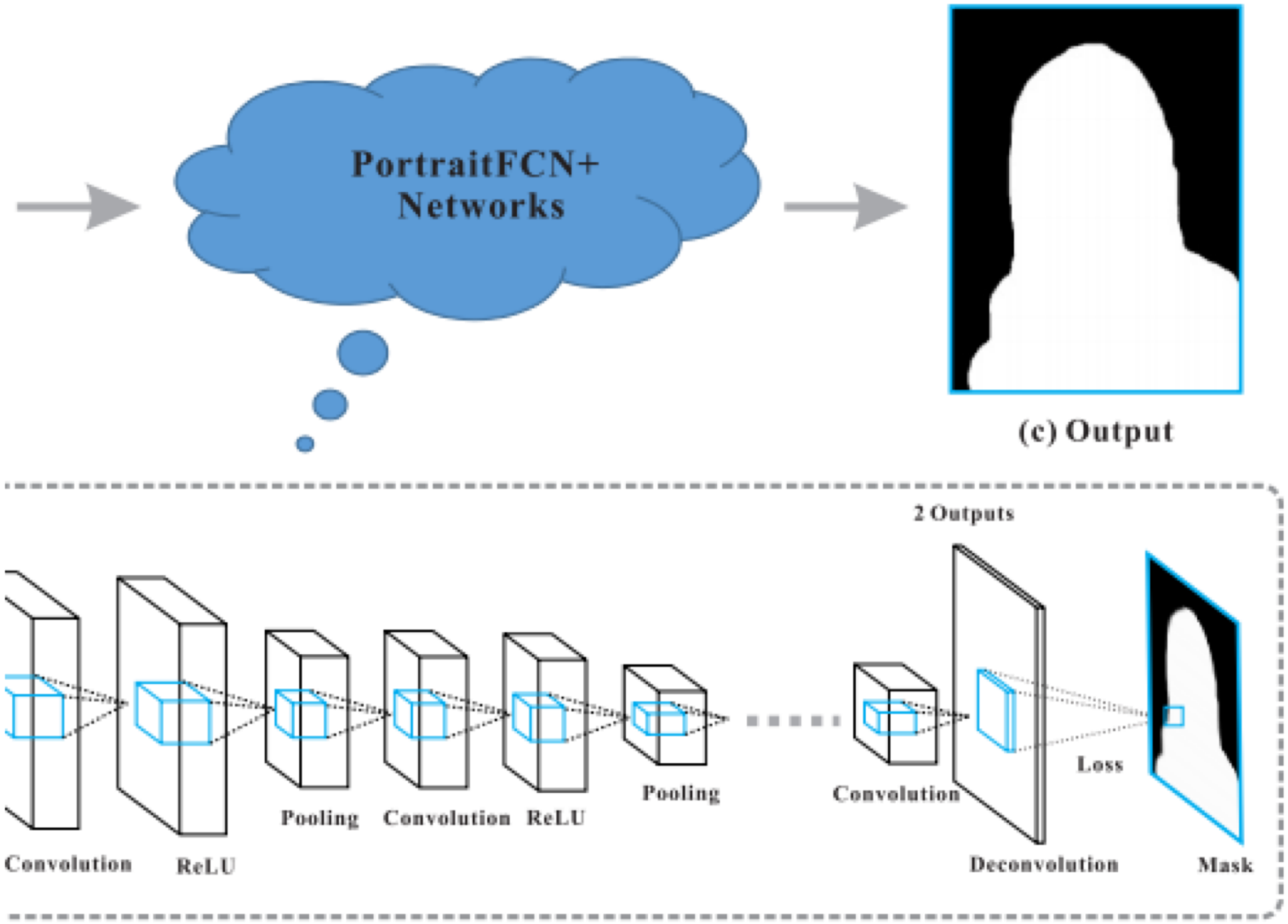
- Augment fully convolutional neural network (FCN) with portrait-specific channels
- Normalized x and y channels: homography transform between facial feature points and canonical pose
- Mean mask channel: subject-shaped region overlaid on actual subject as an estimate of final result

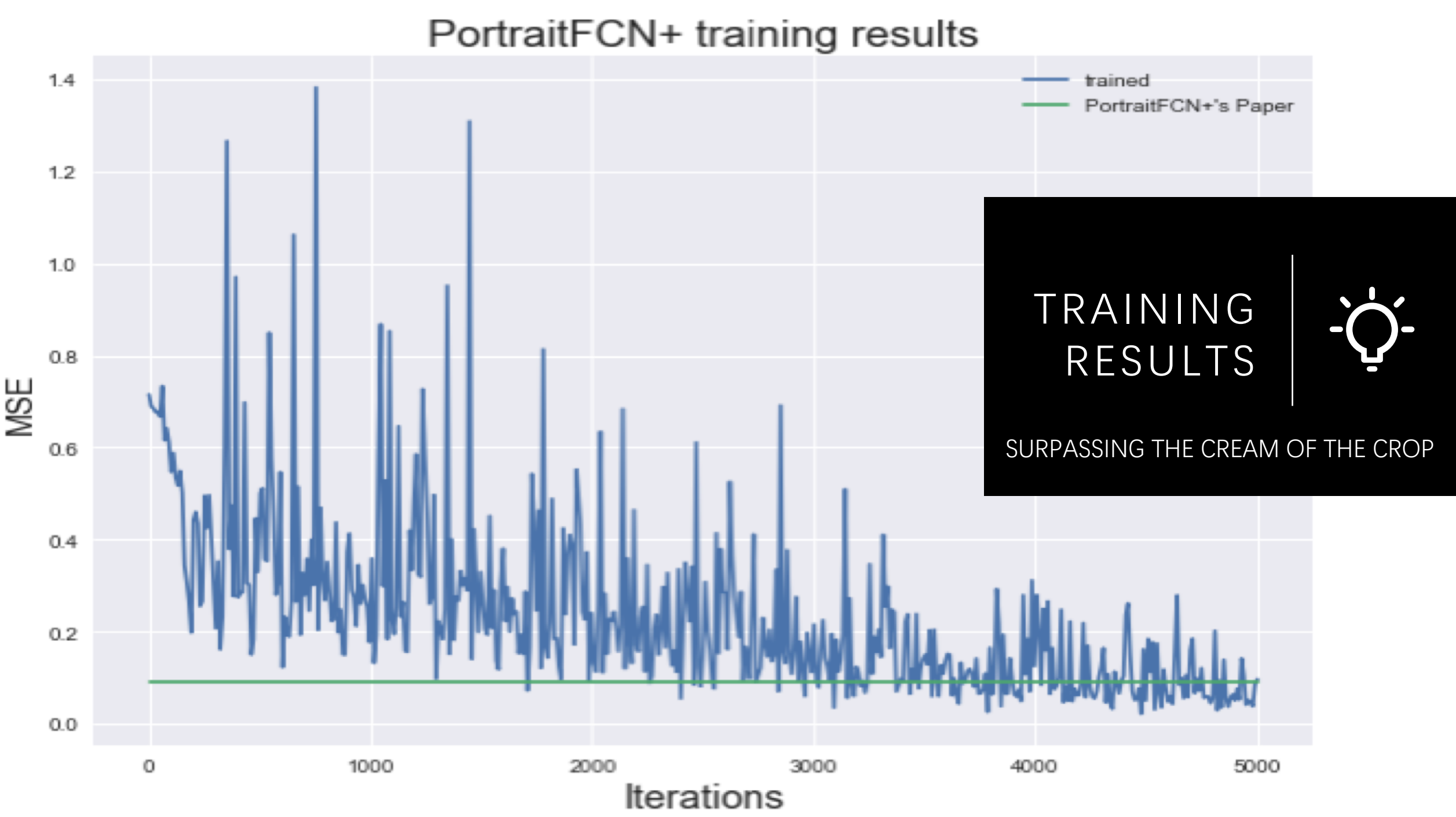


PORTRAIT FCN+

Layers of the neural network

- Convolution: extract image features, such as edges
- ReLU: nonlinear activation function
- Pooling: max or average of feature over a region
- Deconvolution: upsample previous layers to ensure output matches input size
- Loss: measure error between output and ground truth





TRAINING RESULTS

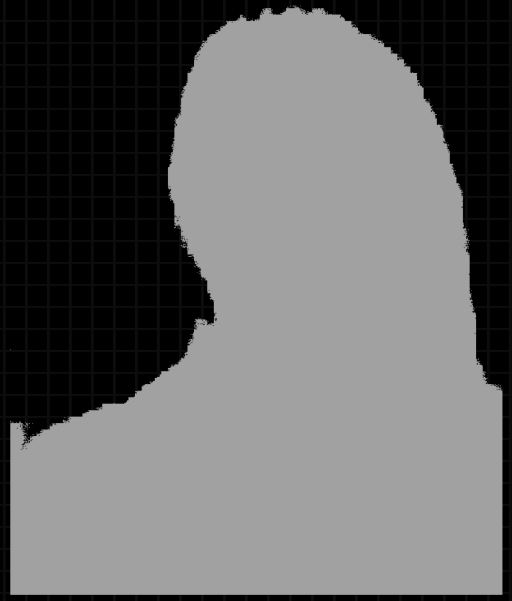
SURPASSING THE CREAM OF THE CROP

TRAINING RESULTS

Comparing to ground truth

01

ORIGINAL



02

PORTRAIT FCN+ MASK
OUR MEAN IOU: 93%

03

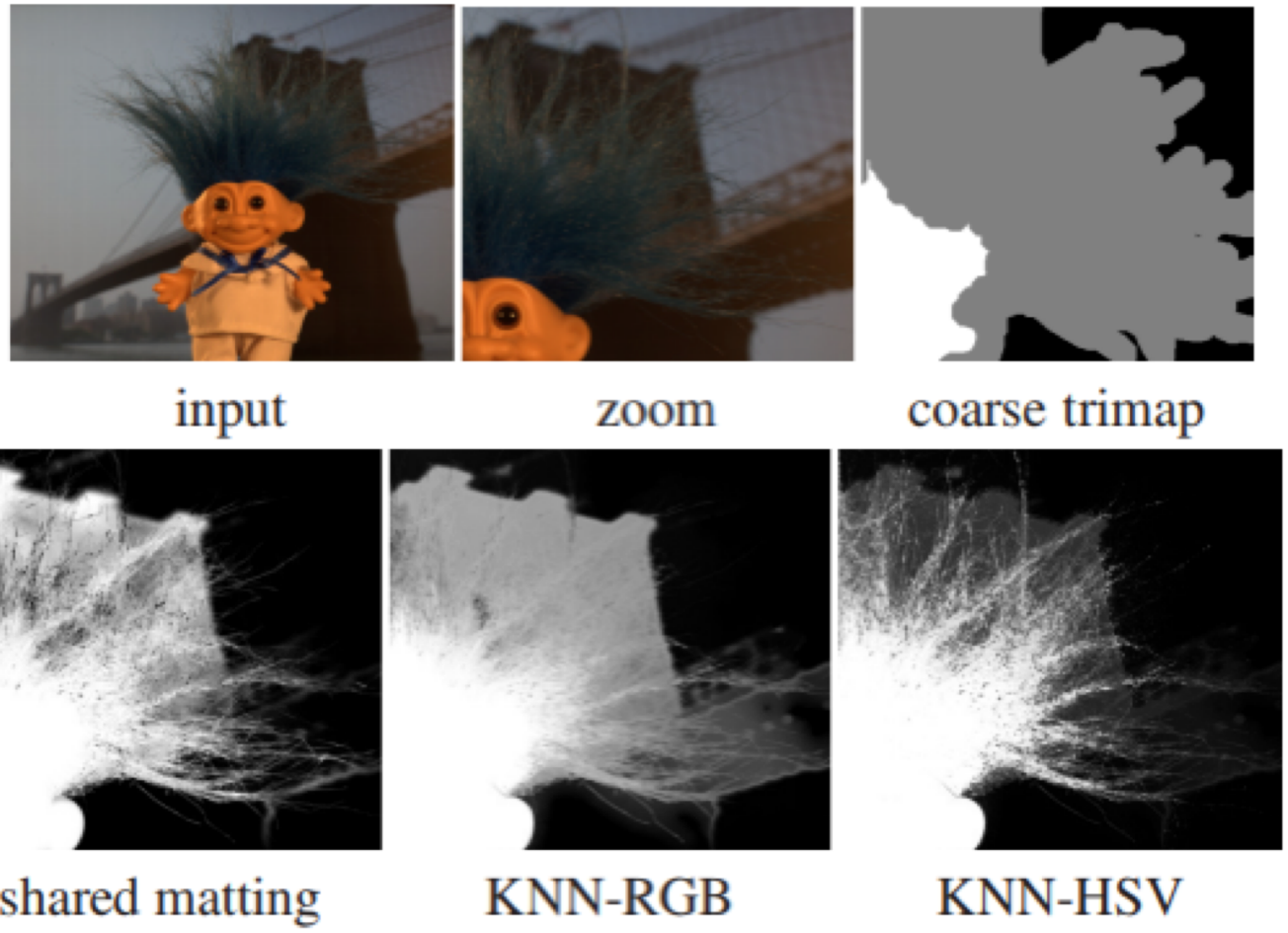
PAPER MEAN IOU: 95%

04

GROUND TRUTH

KNN MATTING

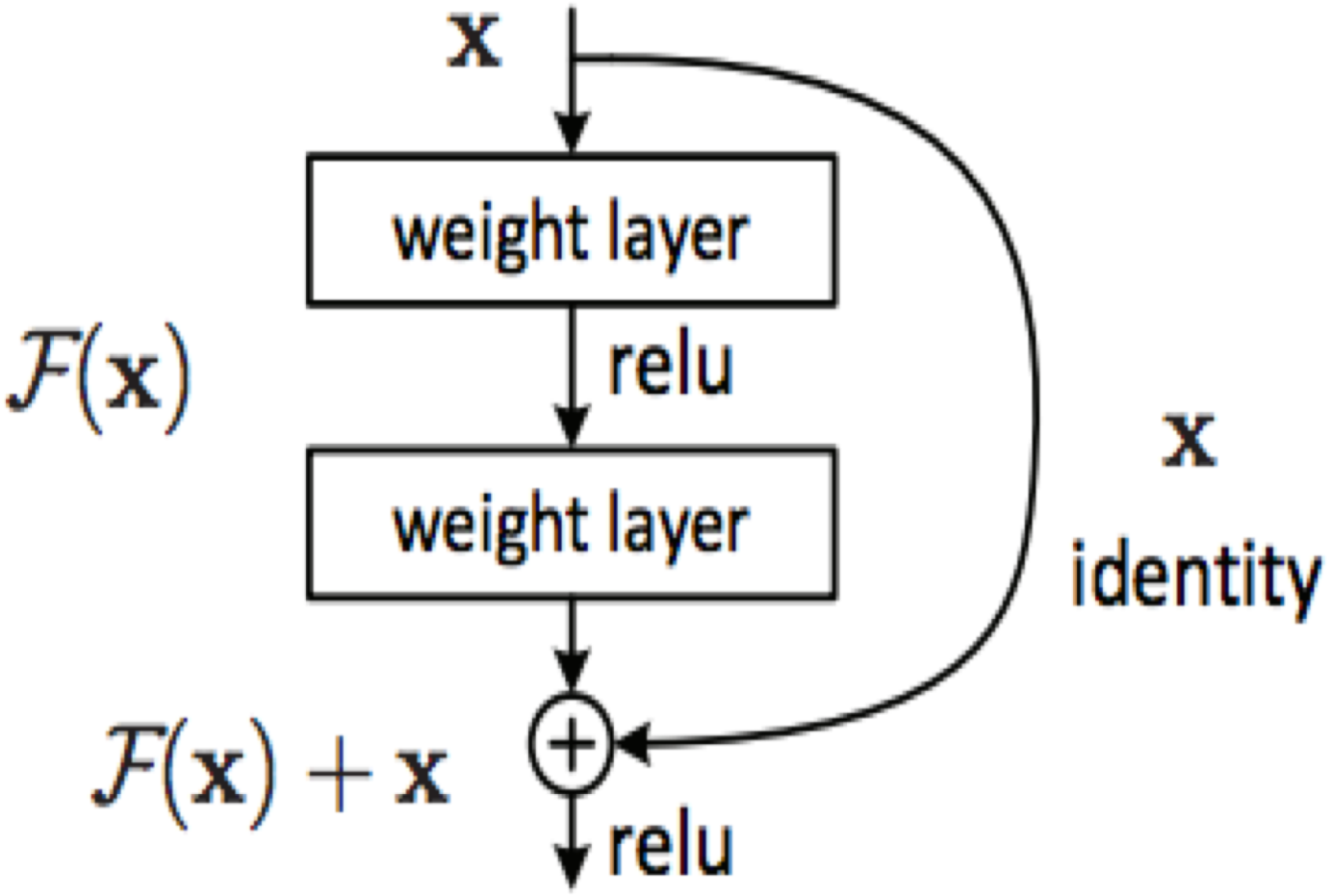
From Trimap to Alpha Matte



- We created trimaps by setting the unknown as 10 pixels away from segmentation boundary of Portrait FCN+
- We then applied it to KNN matting, which uses K nearest neighbours to get closed-form solution
- Closed-form solution utilizes the conjugate gradient method

RESIDUAL NETWORK (RESNET)

Traditionally Used to Avoid Vanishing Gradient, but we use to "refine" alpha matte



- Increased layer of network makes the earlier layers negligible (vanishing gradient)
- Adding the layers leads to high training error
- Imply an identity mapping of the input to create a direct path to the output; the latter layer learns only the residual

KNN MATTING & RESNET Results

From Trimap to Alpha Matte

1 Output of Portrait FCN+ (Mask)

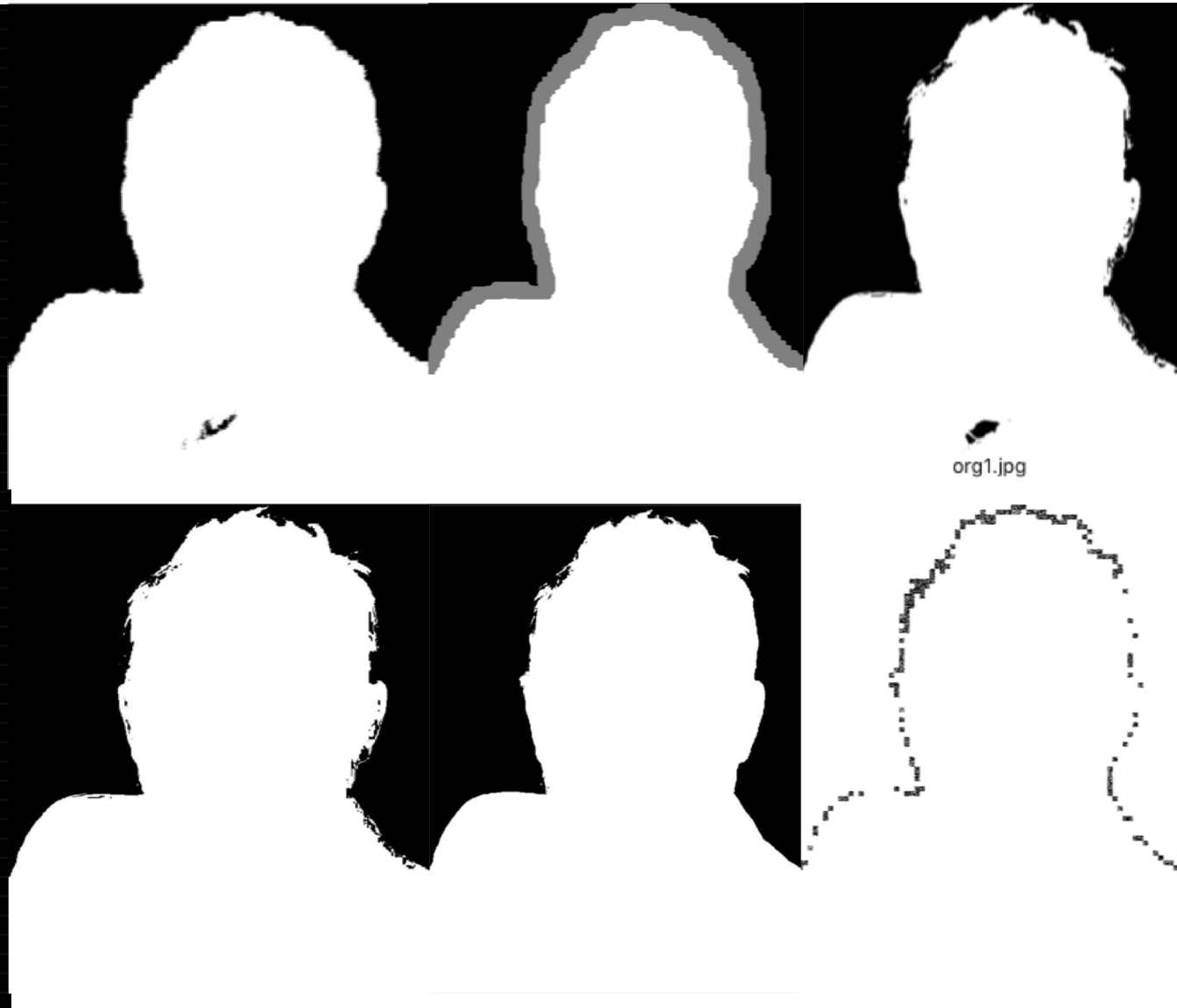
2 Trimap

3 KNN IoU: 95.9%

4 KNN+ Refinement (ResNet) IoU: 97.1%

5 Ground Truth

6 Difference Between 1 & 4



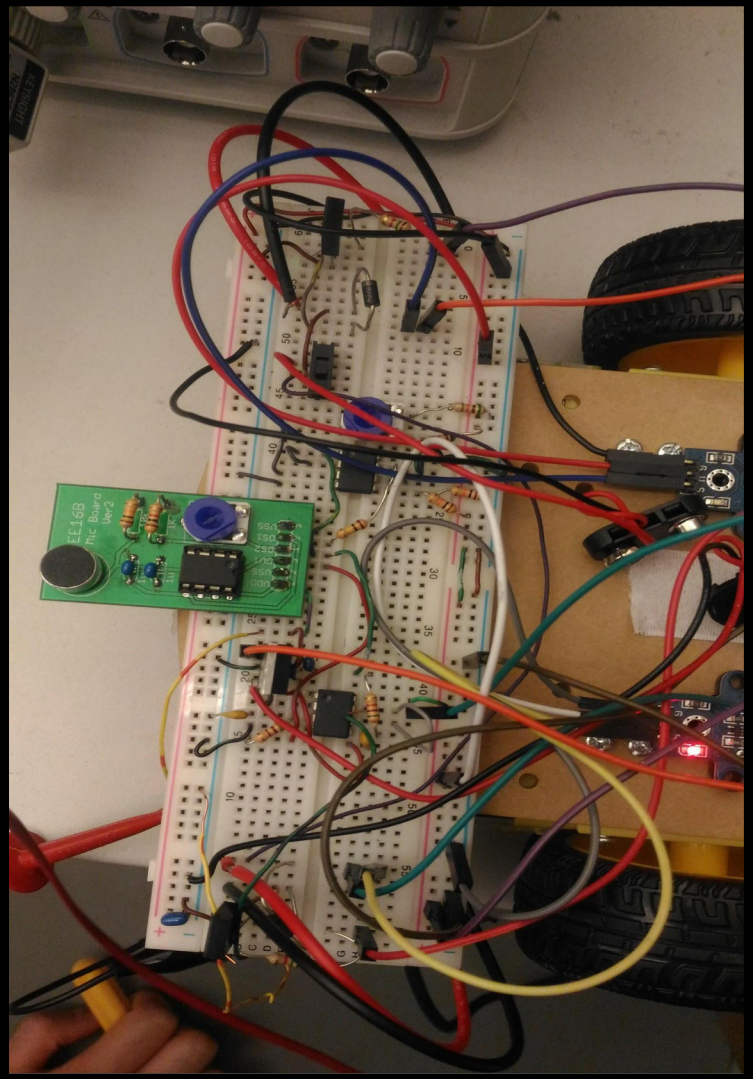
COMPARISON TO DIM (STATE OF THE ART)

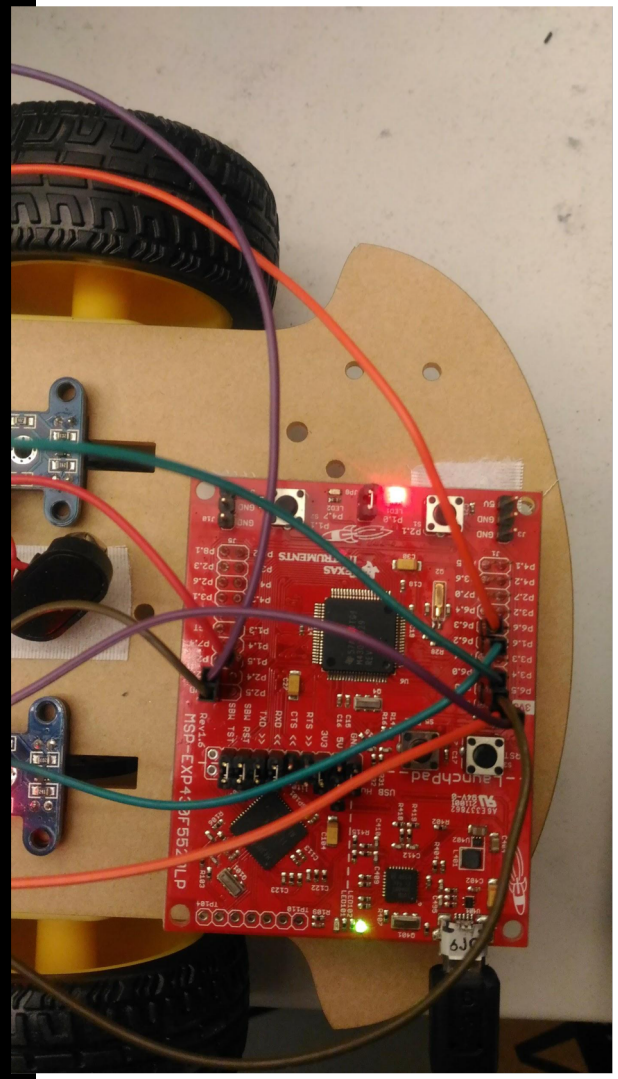
Ours achieved around 97% with KNN

Methods	[13]	[34]	[28]	[16]	[22]	[5]	[8]	Ours
Shared [13]	-	**60.0**	**78.5**	**79.6**	**69.7**	40.6	**57.8**	**83.7**
Learning [34]	40.0	-	**60.2**	**54.6**	**53.4**	27.3	35.1	**83.6**
Comprehensive [28]	21.5	39.8	-	25.8	43.3	20.4	29.2	**78.8**
Global [16]	20.4	45.4	**74.2**	-	**53.3**	30.0	42.0	**84.2**
Closed-Form [22]	30.3	46.6	**56.7**	46.7	-	25.0	38.1	**80.4**
KNN [5]	**59.4**	**72.7**	**79.6**	**70.0**	**75.0**	-	**73.3**	**97.0**
DCNN [8]	42.2	**64.9**	**70.8**	**58.0**	**61.9**	26.7	-	**83.7**
Ours	16.3	16.4	21.2	15.8	19.6	3.0	16.3	-

HARDWARE ADVANTAGE:

KNN-Matting





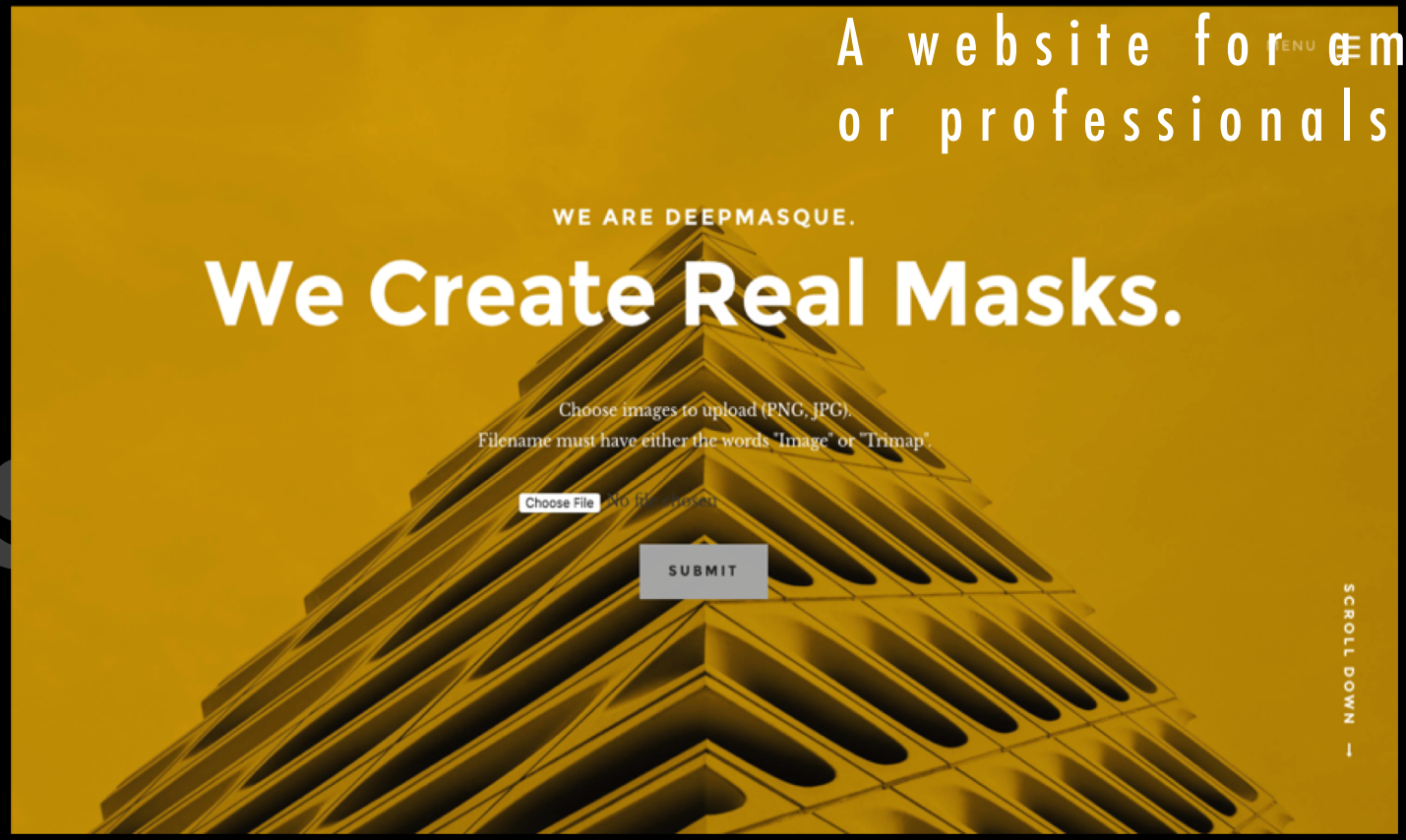
Launchpad: Signal Intake

Applied Signal of length 800 on the micboard which were then projected onto 2 PCA vectors and then applied with KNN as a linear system solver on the spot using a Energia Arduino program. The length 800 voice input represents a column of image which PCA will be applied on.

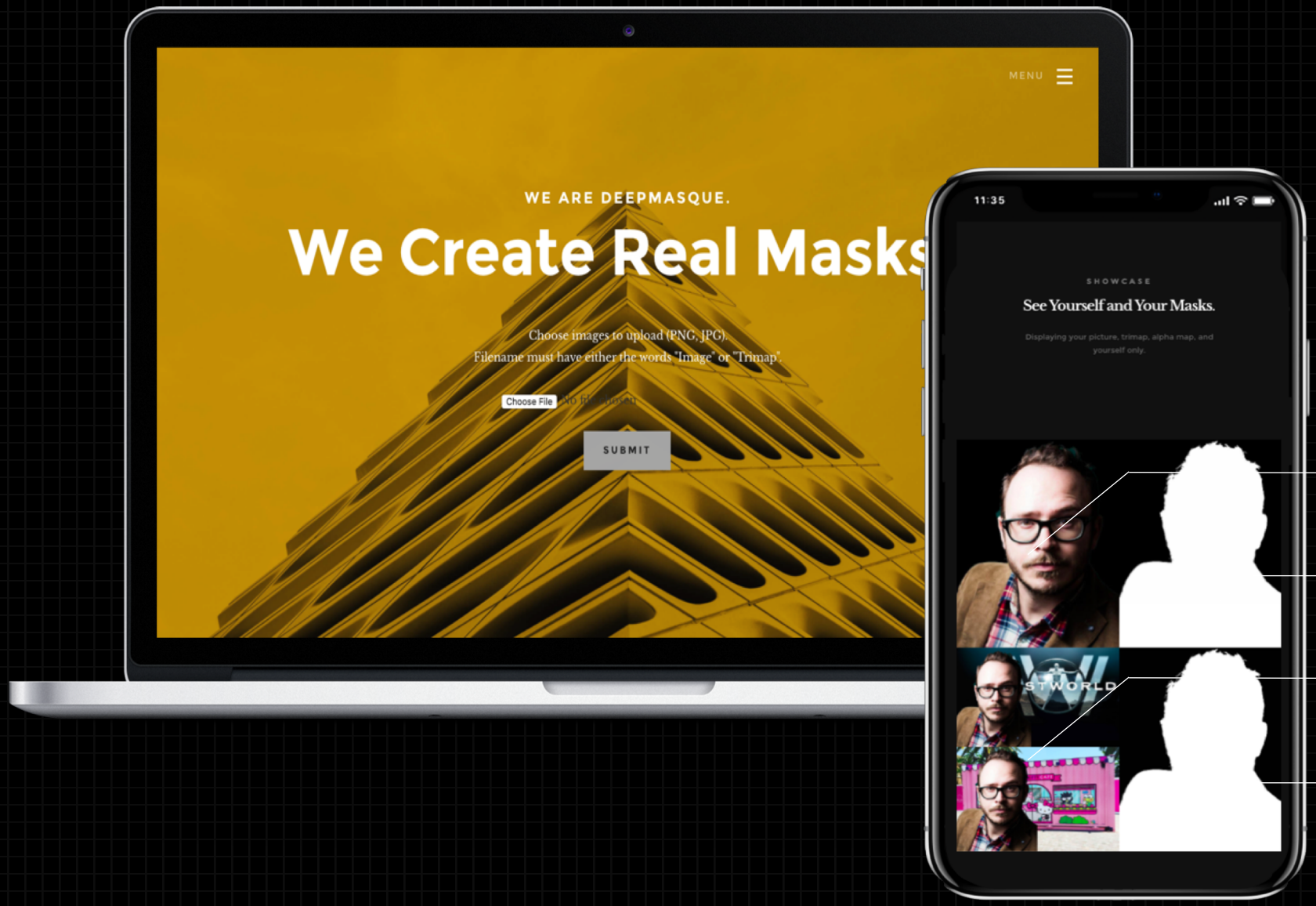
Significance: We prove that the masking interface for the KNN-matting section is capable of operating on a hardware of only 4 KB, virtually nothing by modern standards. This means we essentially have completely wiped out the original state of the art dependency on memory that DIM took up!!

USER INTERFACE

A website for amateurs or professionals



Our website enables the user to upload their picture and submit it to obtain two masks, the trimap and the alpha matte, and a final representation of the subject on a different background.



WEBSITE DEMO

02

Laptop & Cellphone End

"Our website enables the user to upload their picture and submit it to obtain two masks, the trimap and the alpha matte, and a final representation of the subject on a different background."

01. Original Input Image

02. Trimap

03. Final Products

04. Alpha Matte

Low-Tech Demo Goals

- ~~Gain Familiarity with TensorFlow Framework~~
- ~~Develop proficiency in neural networks, CNNs, image segmentation, and FCNs~~
- ~~Understanding two Arxiv papers: 1) Portrait FCN+ 2) Deep Matted Learning Paper~~
- ~~Training datasets for PFCN+ via GPUs (cudas) or AWS (clusters)~~
- ~~Develop Potrait FCN+ and Deep Matted Learning model in Tensorflow~~
- ~~Transform & Present the framework in a user input-allowed format~~

… And Beyond

- Use KNN matting to create alpha matte from trimap
- Create user interface in web and mobile development that produces masking images using our model
- Prove the memory reduction of our model compared to planned model with primitive hardware device via hardware demo
    - Achieved similar IoU to DIM with less costly algorithm, opening a potential renew research into KNN-Matting
        - Kept the whole runtime/process time under ~5 minutes (due to KNN unoptimized)
            - Currently working on 3-D Modeling

LEARNING PATHS

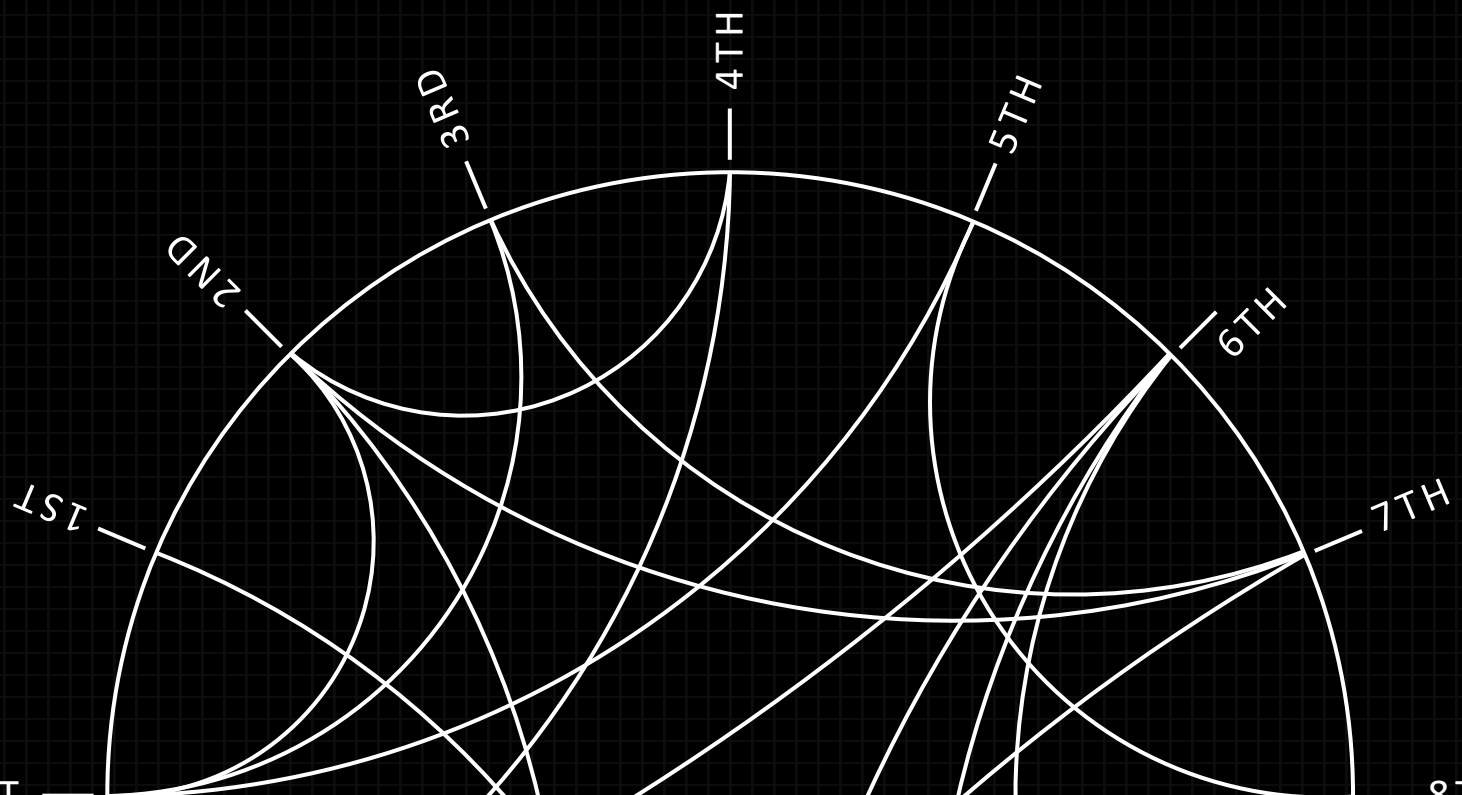
+++

+++++

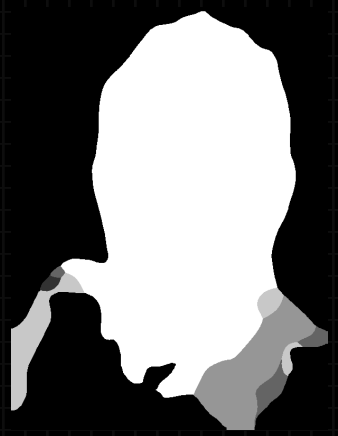
WE STARTED WITH REPRODUCING XIAOYONG SHEN'S PAPER (IN MATLAB) BUT IN TENSORFLOW.

- 0TH POINT: LEARNING TENSOR-FLOW AND DEEP LEARNING/COMPUTER VISION FOR THE FIRST TIME
  - WE FIRST DID A FCN-8S (USED IN SEGMENTATION FOR SELF-DRIVING CAR) TO SEE HOW THAT WOULD LOOK LIKE. THE LOW IOU WAS ~55%

- 1ST ITERATION - WE THEN IMPLEMENTED PORTRAITFCN+ WHICH HAD MULTIPLE ISSUES:
  - 1) WE DIDN'T SPECIFY PADDING (SO TENSORFLOW JUST MADE THE INCORRECT PADDING FOR US)
  - 2) BUGS WHICH WE FIXED BY USING TF.LAYERS LIBRARY INSTEAD OF TF.NN
  - 3) INCORRECT LOSS FUNCTION AND
  - 4) FAILED TO RUN CAFFE IN TENSORFLOW (WHERE IN PAPER, XIAOYONG & HER TEAM USED CAFFE IN MATLAB) (ACCURACY: 75% IOU)



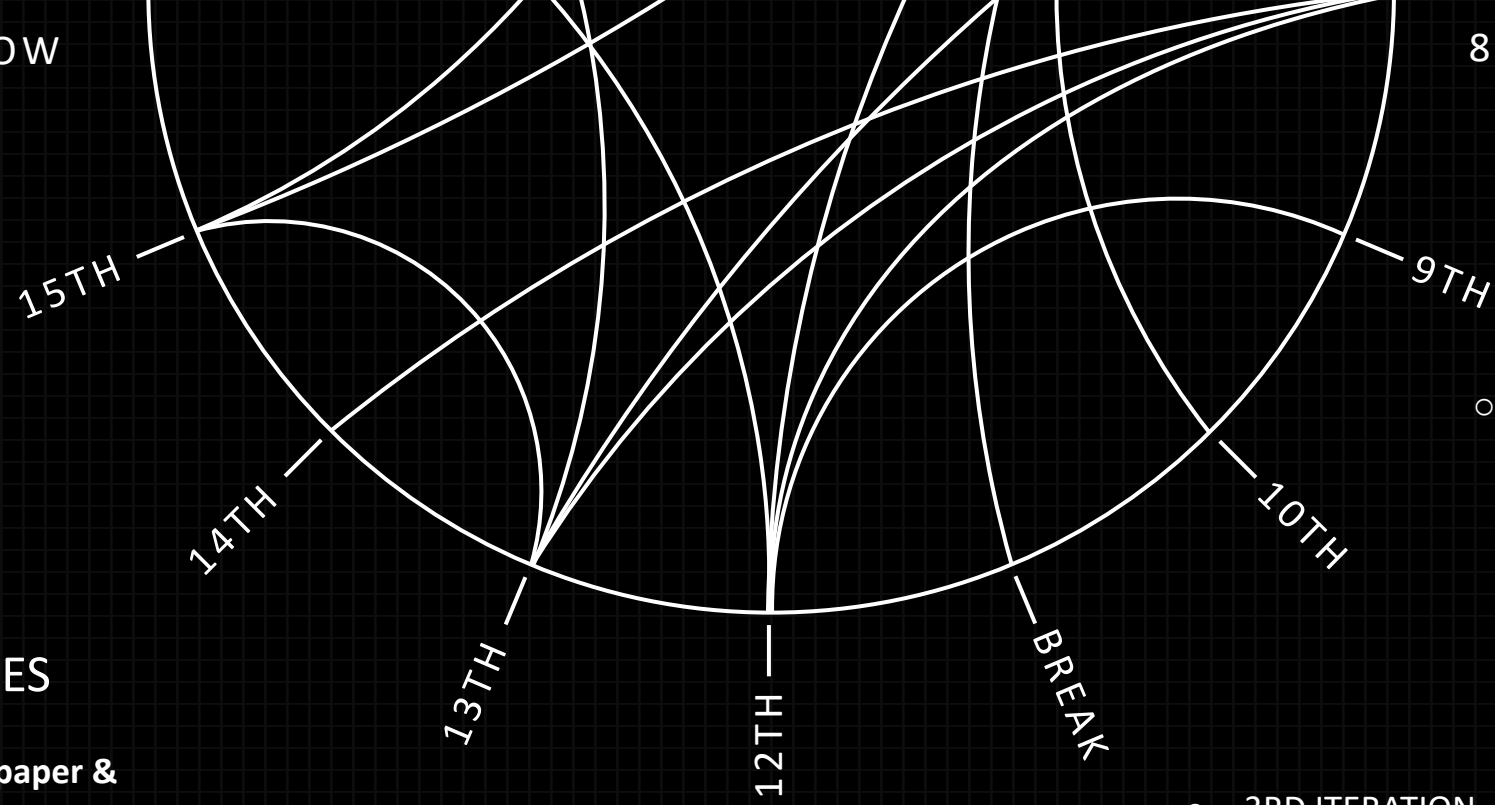
WE TRIED TRAINING LOCALLY AND THAT FROZE THE LAPTOP, SO WE TRAINED ON 8 CPUS/2 GPUS ON AWS.



01

LEARNING OUTCOMES

- **Analyzing research paper & realizing and validating the implementation of paper**
- **Learned how to use/setup AWS**
- **Learned encoder-decoder network, Resnet, fcn-8s**
- **Computer vision techniques, transforms, Portrait FCN+, KNN application to masking**
- **Basic web development**
- **Facial feature extraction & image rotations**
- **Importance of reproducibility**



- 2ND ITERATION - FIXED ALL THE BUGS AND INITIALIZE THE CONV-NET PORTION OF PORTRAIT FCN+ WITH VGG (ACCURACY 92%)
- 3RD ITERATION - WE TRAINED THE CONV-NET WITHOUT INITIALIZATION, WHICH DIDN'T CONVERGE (ACCURACY 70% IOU)
  - WE RECEIVE A REPLY FROM THE DIM PEOPLE THAT THEIR DATA CANNOT BE USED FOR ANY COMMERCIAL PURPOSES, WHICH COMPLICATED OUR MENTORSHIP WITH TWINDOM.
- 4TH ITERATION - WE REALIZED THAT PORTRAIT FCN+ MIGHT WORK WELL WITH KNN-MATTING. IMPLEMENTED THE KNN-MATTING.
- 5TH ITERATION - ADDED RESNET AND SOME POST-PROCESSING TO IMPROVE IOU (96% IOU)
- IMPLEMENTED ***TWO*** ITERATIONS OF UI

References & Bibliography

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7. K. He, C. Rhemann, C. Rother, X. Tang, and J. Sun. A global sampling method for alpha matting. In CVPR’11, pages 2049–2056, 2011.
8. S. Bell and K. Bala. Learning visual similarity for product design with convolutional neural networks. ACM Trans. Graph., 34(4):98:1–98:10, 2015.

02

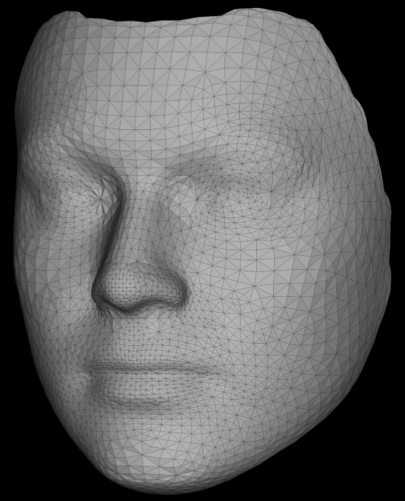
May

AS OF >

3D Morphable Face Model

Isomap texture extraction

- to obtain a pose-invariant representation of the face texture
- Linear scaled orthographic projection camera pose estimation
- Linear shape-to-landmarks fitting
- Expression fitting, and 6 linear expression blendshapes
- Edge-fitting, heavily inspired



Surrey Morphable Face Model

Surrey Face Model is a PCA model of shape variation built from 3D face scans. It comes with uv-coordinates to perform texture remapping

WE ARE DEEPMASQUE

THANK YOU

Questions?

https://github.com/leoli3024/Portrait-FCN-and-3D-reconstruction