IEEE Video and Image Processing Cup 2021

Privacy Preserving In-Bed Human Pose Estimation

Team NFP-Undercover

Department of Electronic and Telecommunication Engineering,

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Team Members :

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Graduate Member : Ashwin De Silva

Supervisor : Dr. Chamira Edussooriya

Task

LWIR Imaging Modality

RGB Imaging Modality

- Occlusion – Partially
- High Resolution
- Illumination Changes
- Accurate Pose Estimation
- Annotations

Human Pose Estimation

Robust Human Pose Estimation

- Non-Contact
- Illumination Changes
- Labeled & Uncovered
- Unlabeled & Covered

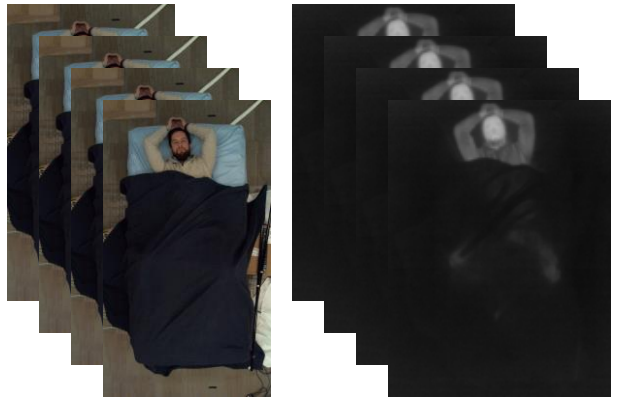
Shuangjun Liu and Sarah Ostadabbas, “Seeing under the cover: A physics guided learning approach for in-bed pose estimation,”22nd International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI2019), Shenzhen, China. arXiv preprint arXiv:1907.02161, 2019.

Task

Training Dataset

Uncovered

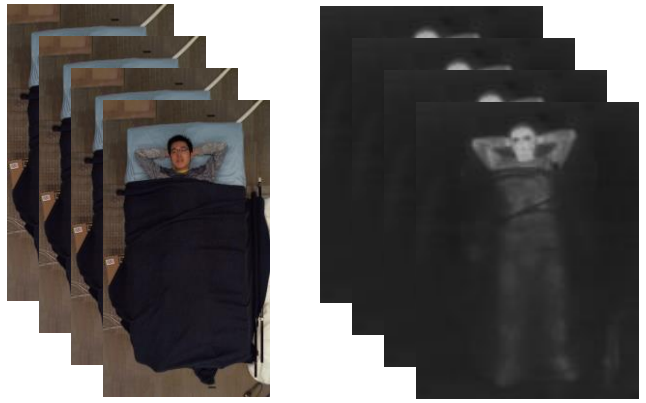
Labeled



Covered

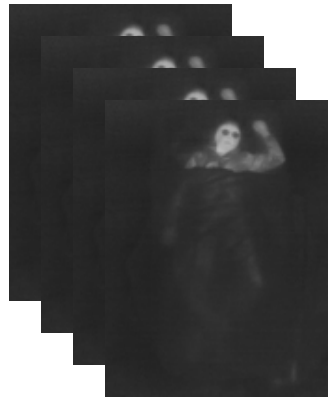
Unlabeled

Validation Dataset



Covered & Labeled

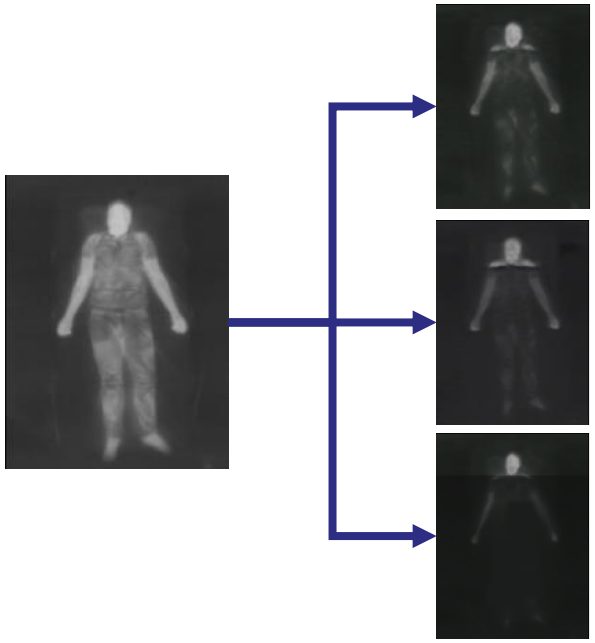
Test Dataset



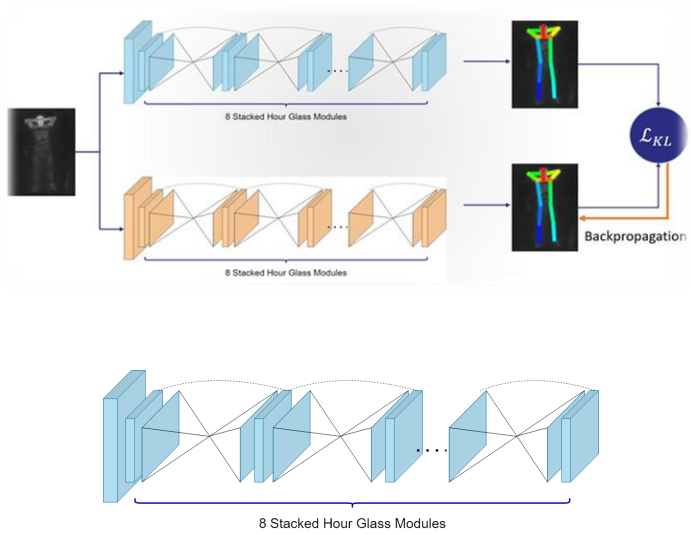
Covered

S. Liu and S. Ostadabbas, “Seeing under the cover: A physics guided learning approach for in-bed pose estimation,” in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 2019, vol. 11764 LNCS.

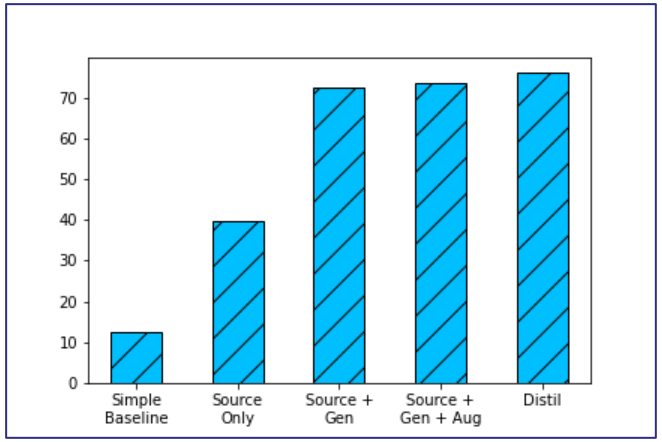
Our Contribution



Two-fold Data Augmentation for Cross-Domain Discrepancy Reduction



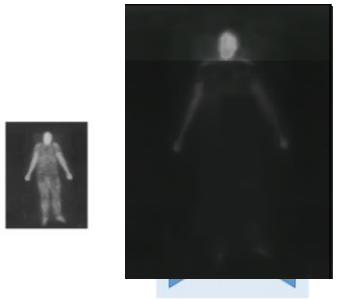
Adapting Simple Stacked Hourglass Model for Cross Domain In-bed Pose Estimation

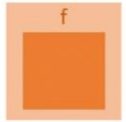


Ablation and Analysis

Algorithm: Overview

Data Augmentation



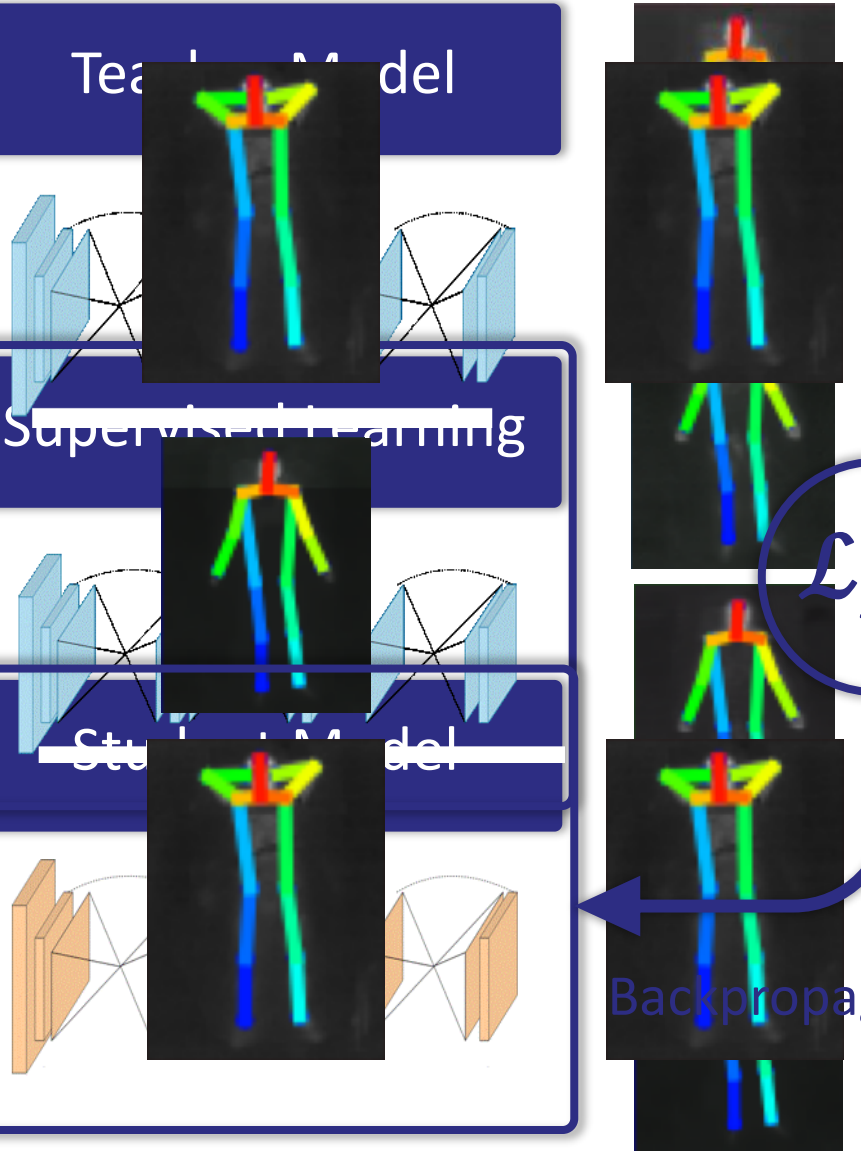


Knowledge Distillation

Teacher Model

Supervised Learning

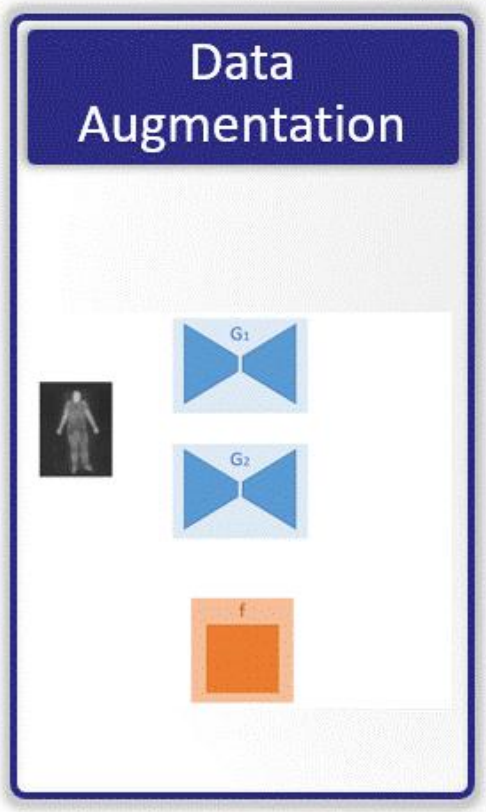
Student Model



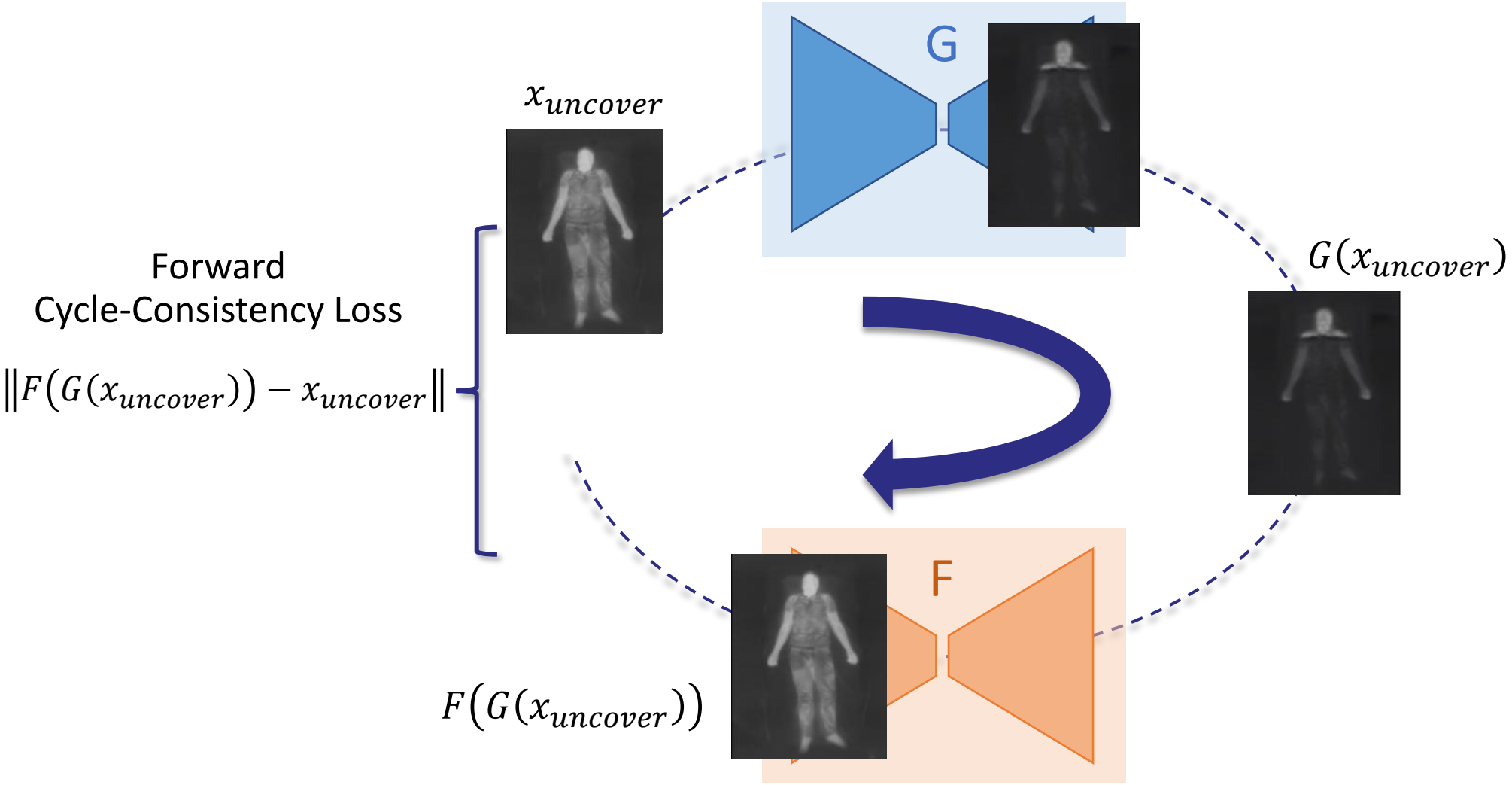
$\mathcal{L}_{KL}$

Backpropagation

Two-fold Data Augmentation for Cross-Domain Discrepancy Reduction



Augmentation 1: CycAug (Training)



J. Y. Zhu, T. Park, P. Isola, and A. A. Efros, "Unpaired Image-to-Image Translation Using Cycle-Consistent Adversarial Networks," in *Proceedings of the IEEE International Conference on Computer Vision*, 2017, vol. 2017-October.

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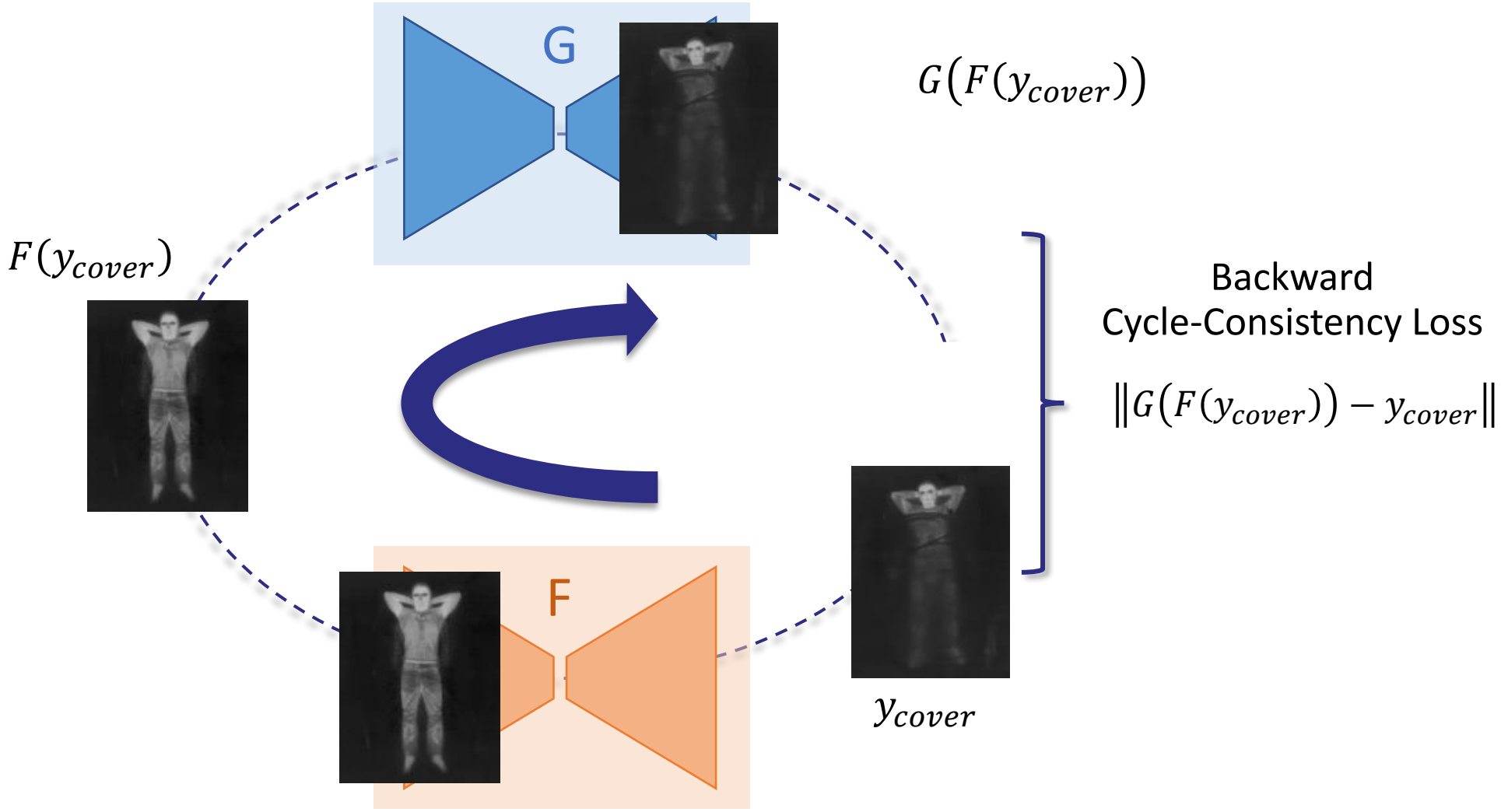

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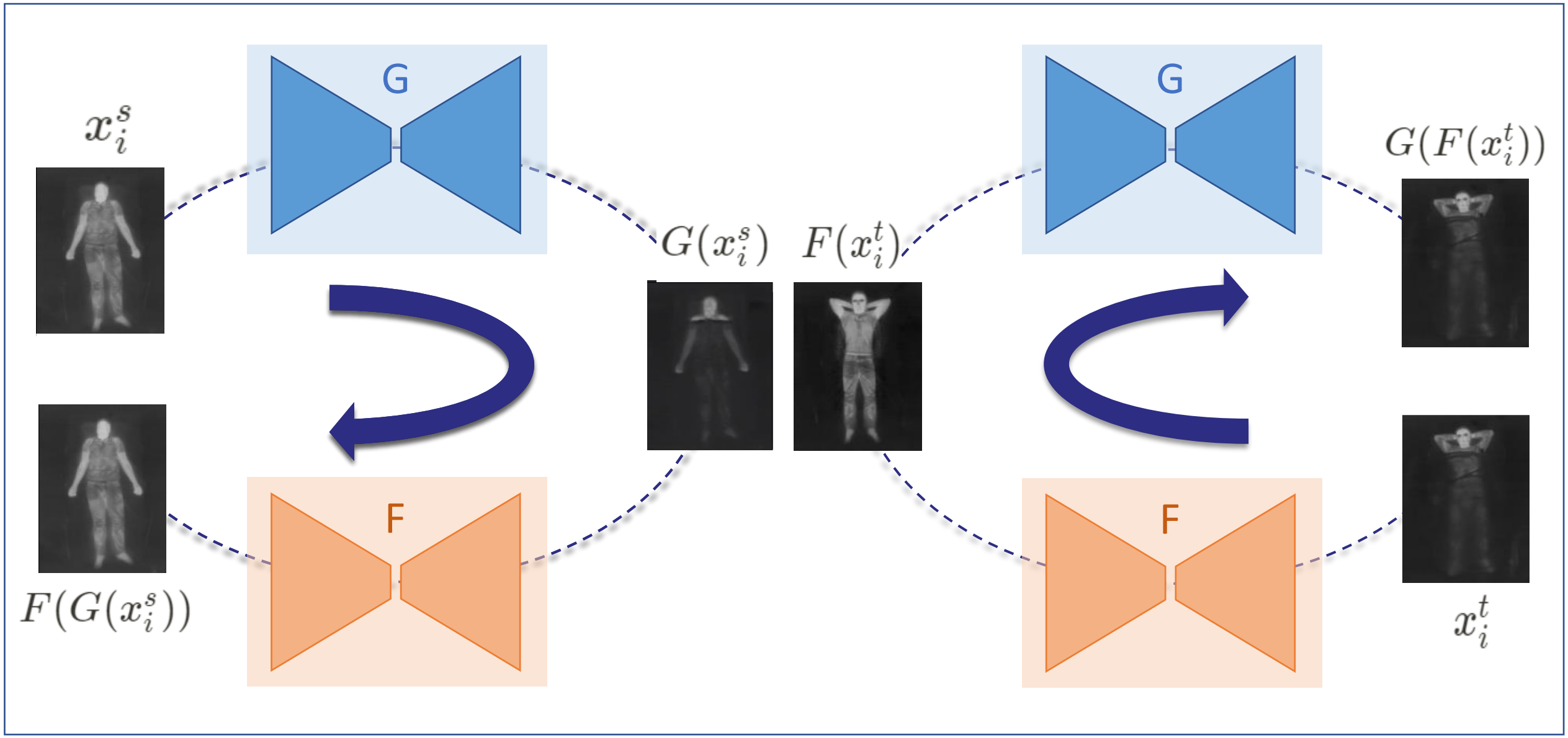
G
G
x_i^s
$G(x_i^s)$
$F(x_i^t)$
$G(F(x_i^t))$
F
F
$F(G(x_i^s))$
x_i^t

Augmentation 1: CycAug (Training)

$$Loss = Adversarial\ Loss + (\lambda \times Cycle\ Consistency\ Loss)$$

More Realistic

Unpaired Translation

$$\mathcal{L}_{GAN}(G, D_y, X_{uncover}, Y_{cover}) + \mathcal{L}_{GAN}(F, D_x, Y_{cover}, X_{uncover}) + \lambda$$

$forward\ cyc\ loss$

$backward\ cyc\ loss$

$$\mathrm{E}_{x \sim p_{data}(x_{uncover})}[\|F(G(x_{uncover})) - x_{uncover}\|] + \mathrm{E}_{y \sim p_{data}(y_{cover})}[\|G(F(y_{cover})) - y_{cover}\|]$$

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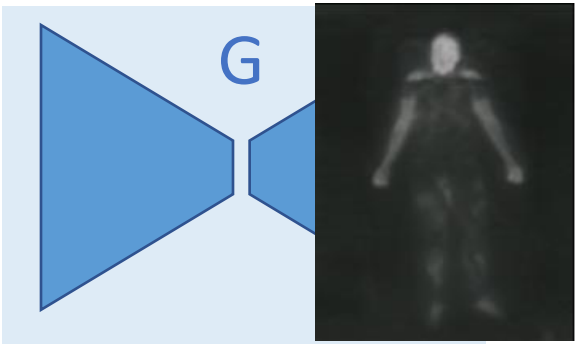
Augmentation 1: CycAug (Inferencing)

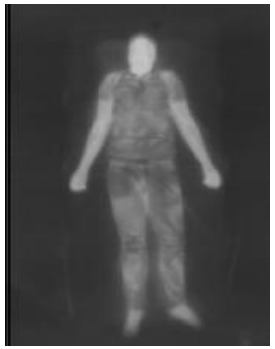
Uncovered LWIR Image



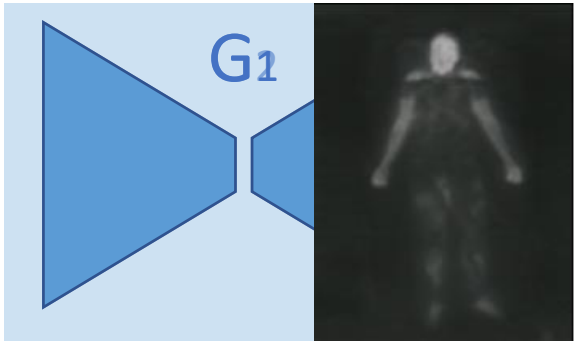
Generator

Generated Covered LWIR Image

Augmentation 1: CycAug (Inferencing)



Uncovered LWIR Image



Generator for Thin Cover

Generated Thin Covered LWIR Image

Generator for Thick Cover

Generated Thick Covered LWIR Image

Augmentation 2: ExtremeAug

Augmentation 2: ExtremeAug

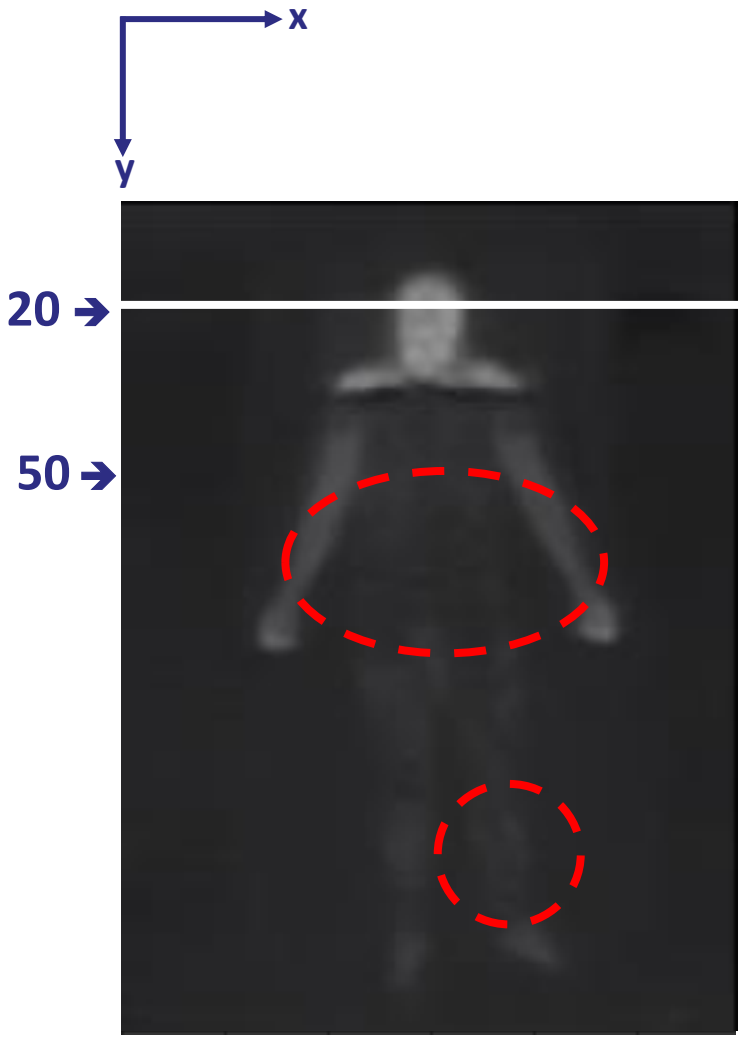
Select random value r ϵ [20,50]

$$X_{cover}(x,y) = \frac{X_{cover}(x,y)}{2}, if\ y \geq r$$

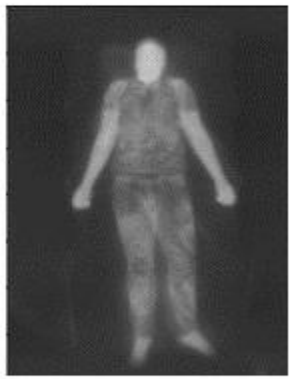
Add random dark kernels below r

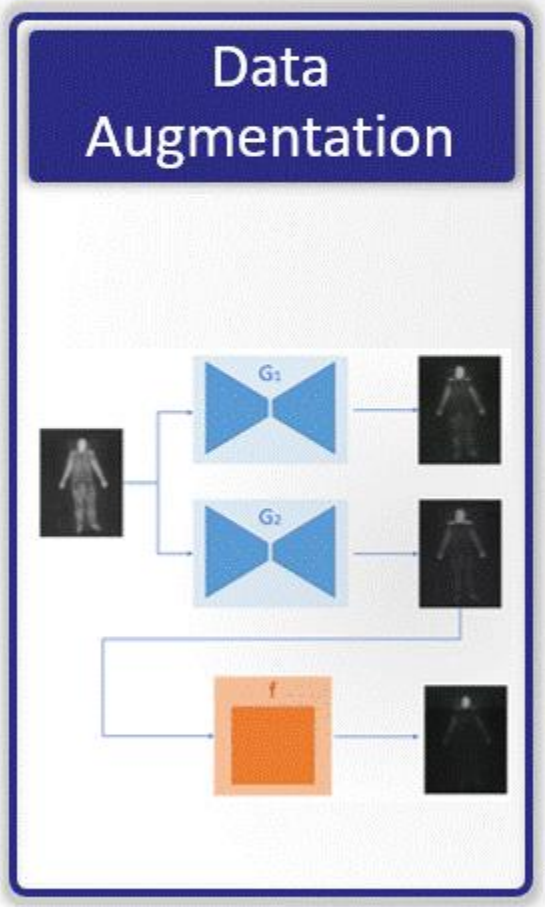
Morphological Operation (Erosion)

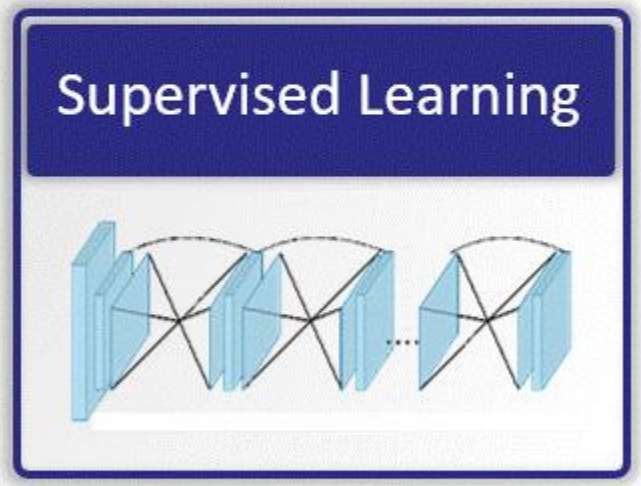
Gaussian Blurring



Supervised Learning : Pose Estimation







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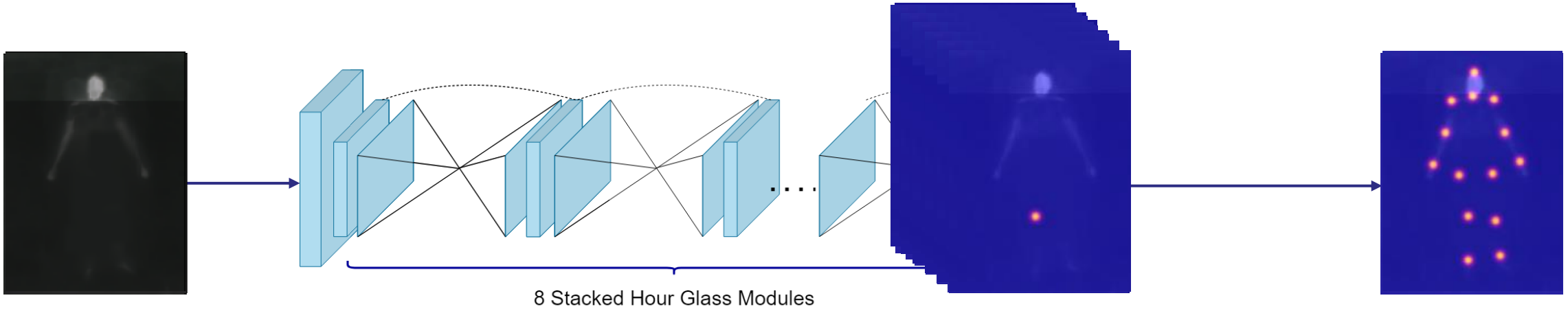
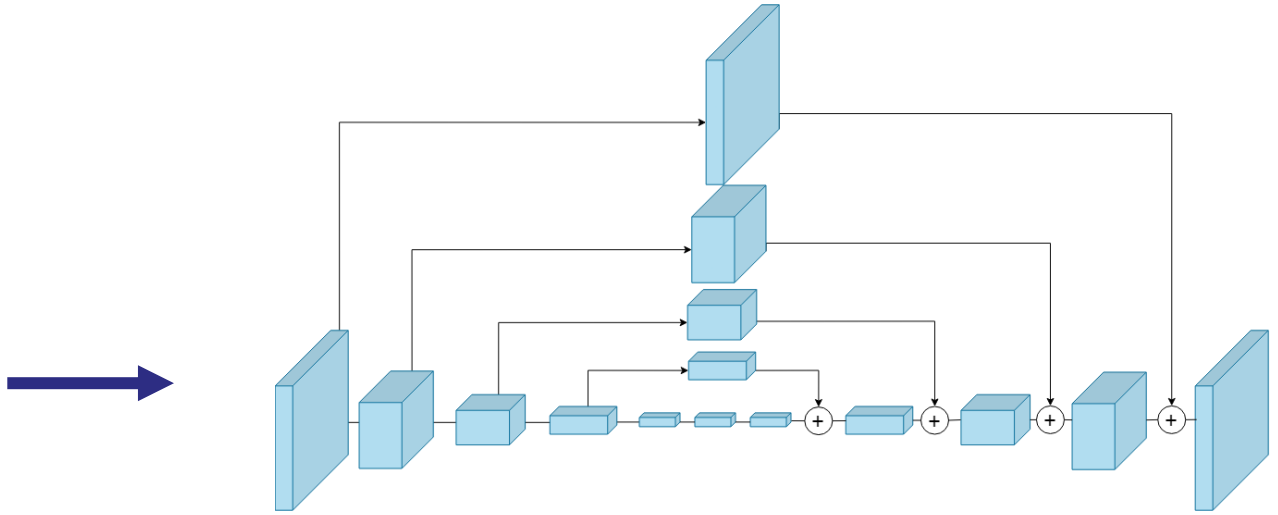
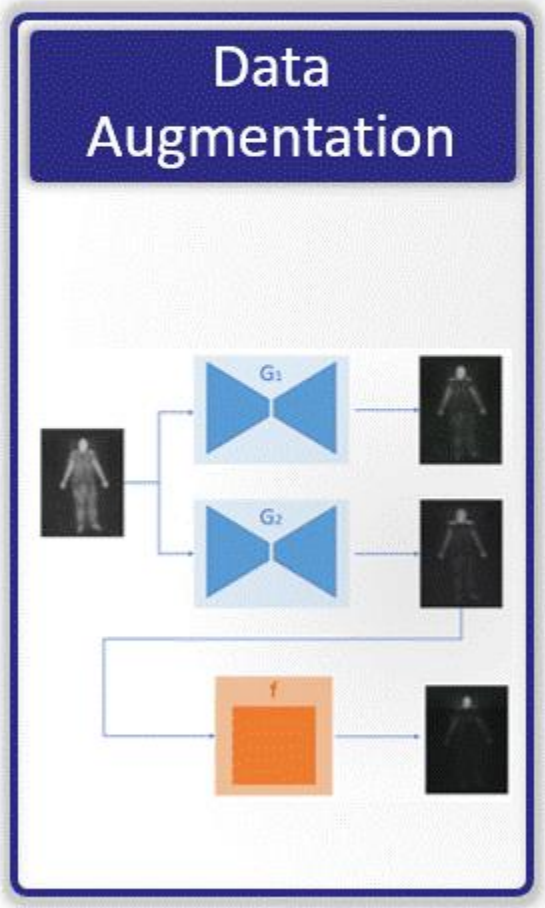




$$\mathcal{L}_{MSE\_Pose}$$

Alejandro Newell, Kaiyu Yang, and Jia Deng. Stacked hour- glass networks for human pose estimation. In *ECCV*, pages 483–499, 2016

Knowledge Distillation



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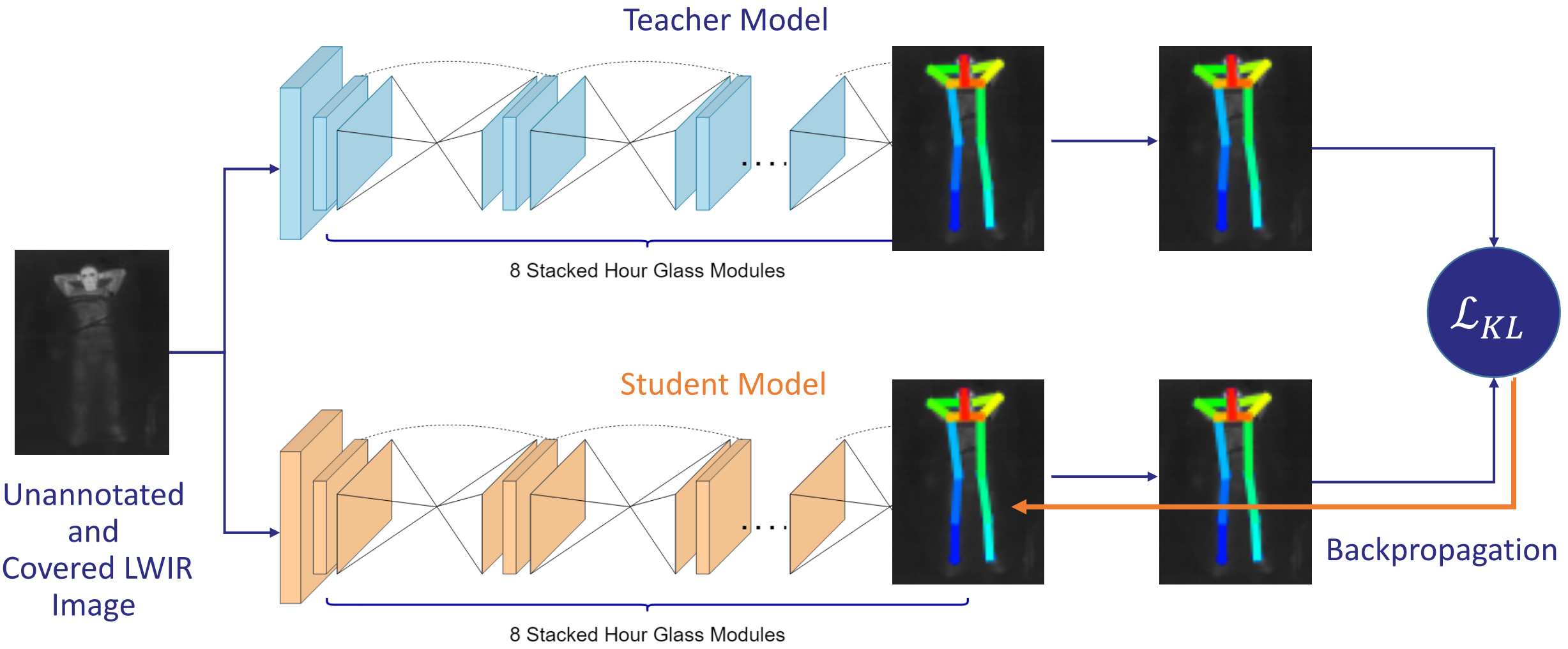

G. Hinton, O. Vinyals, and J. Dean. Distilling the knowledge in a neural network. *arXiv preprint arXiv:1503.02531*, 2015.
Kullback S, Leibler RA On information and sufficiency. Ann Math Stat 22:79–86

Results (Test1)

Method	pckAUC	pck@0.2	pck@0.5	pckAUC - hospital	pckAUC - home
Simple Baseline [1]	5.96	3.21	12.41	7.48	4.95
Source (Uncover) data only [2]	21.78	15.59	39.52	21.55	21.93
Uncover data + CycAug	46.42	40.22	72.44	46.57	46.32
Uncover data + CycAug + ExtremeAug	47.16	40.46	73.38	47.48	46.95
Uncover data + CycAug + ExtremeAug + Knowledge Distillation	**49.8**	**43.65**	**76.13**	**50.62**	**49.25**

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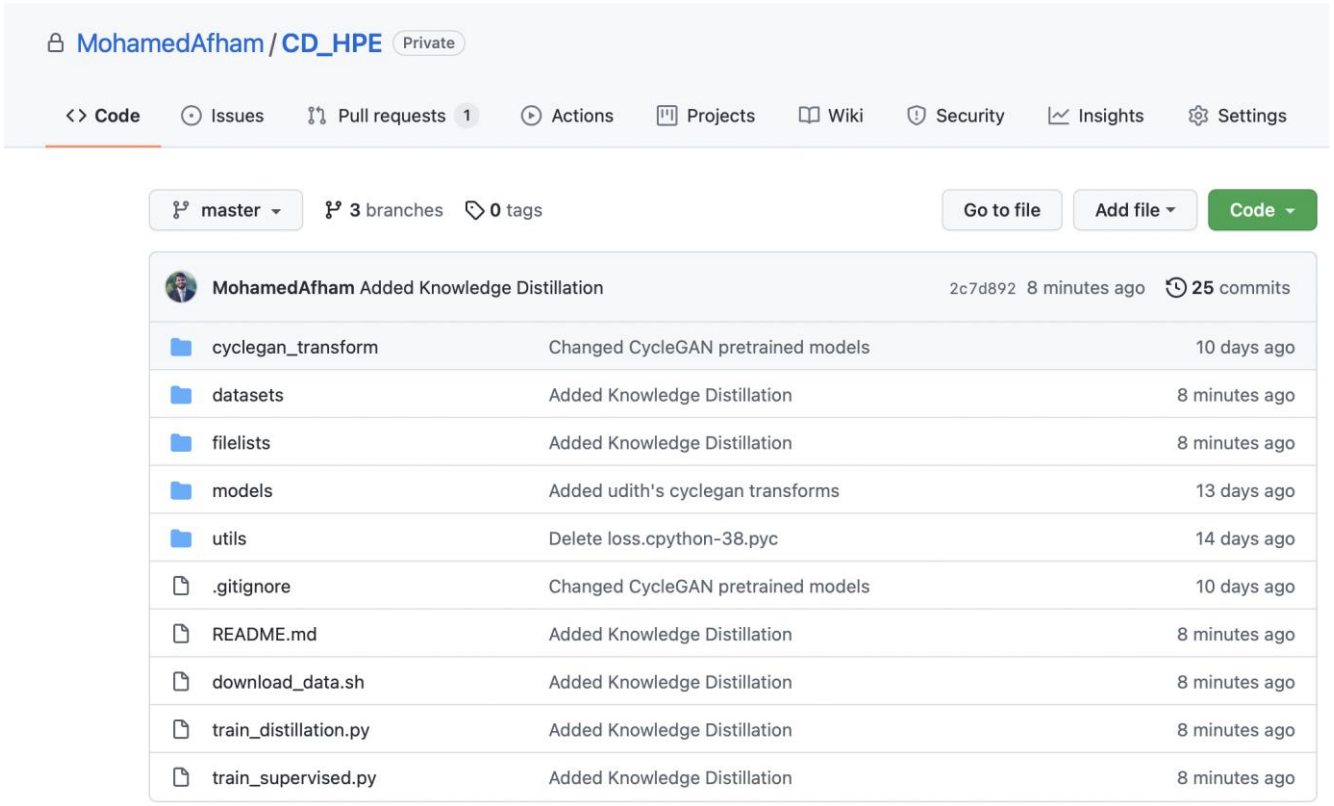
Results (Test2)

Method	pckAUC	pck@0.2	pck@0.5	pckAUC - hospital	pckAUC - home
Our best model	**50.065**	**42.187**	**77.46**	**50.270**	**49.963**

Estimated Prediction Time per image	
With CPU	**With GPU**
1.3512 s	**0.14069 s**

Reproducibility



Link to GitHub Repo: https://github.com/MohamedAfham/CD_HPE

SCAN ME

README.md

Cross Domain - Human Pose Estimation

VIPCUP 2021 - Team NFP_Undercover

Pose Definition

We follow the Leeds Sports Pose Dataset pose definition with 14 joints labeling, namely,

`Right ankle Right knee Right hip Left hip Left knee Left ankle Right wrist Right elbow Right shoulder Left shoulder Left elbow Left wrist Neck Head top`

The lable matrix `joints_gt_<modality>.mat` has the format `<x,y,if_occluded>` x n_joints x n_subjects

Dataset

Create a folder named data/SLP_VIPCup.

```
mkdir data
cd data
mkdir SLP_VIPCup
cd ..
```

Download dataset from codalab. Unzip the data inside data/SLP_VIPCup/ by running:

```
source dowload_data.sh
```

The directory should look like

```
CD_HPE/
    data/
        SLP_VIPCup/
            train/
            test1/
            val/
```

Run the following to create the required `.json` files for the dataset

```
cd filelists
source create_filelist.sh
cd ..
```

Train

For Learning Stage 01 (Standard Supervision)

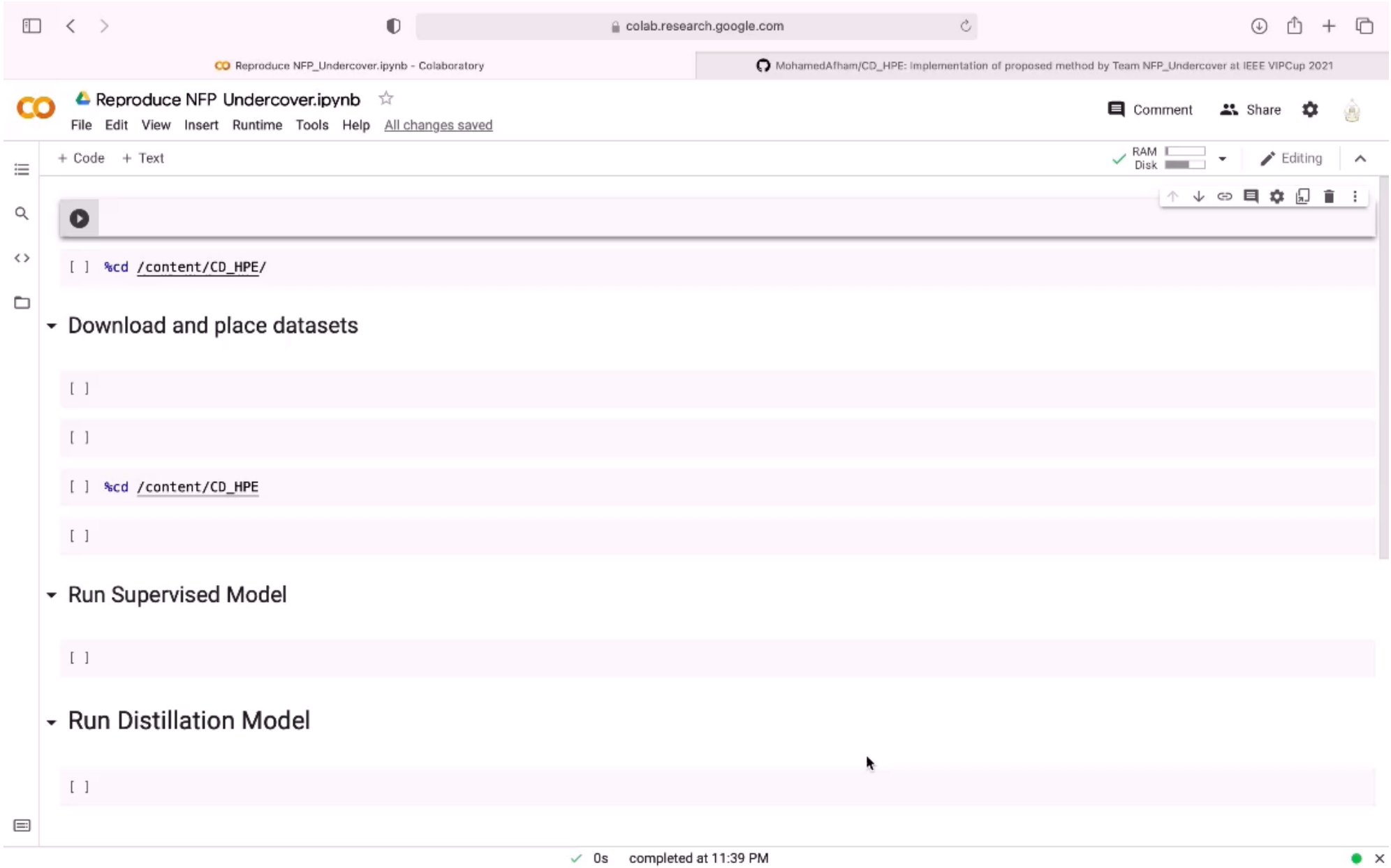
```
python train_supervised.py --adam --use_target_weight --model stacked_hg -
```

For Learning Stage 02 (Knowledge Distillation)

```
python train_distillation.py --adam --best_path path/to/best/model --model
```

Conclusion

- ✓ **Domain Adaptive**
- ✓ Two-fold Data Augmentation for Cross-Domain Discrepancy Reduction
- ✓ Two – Stage **novel** learning pipeline
- ✓ Agnostic to modality
- ✓ Trainable using **limited resources**
- ✓ Code **publicly** available


colab.research.google.com
Reproduce NFP_Undercover.ipynb - Colaboratory
MohamedAfham/CD_HPE: Implementation of proposed method by Team NFP_Undercover at IEEE VIPCup 2021
Reproduce NFP Undercover.ipynb
File Edit View Insert Runtime Tools Help All changes saved
Comment
Share
+ Code + Text
RAM
Disk
Editing
[ ] %cd /content/CD_HPE/
Download and place datasets
[ ]
[ ]
[ ] %cd /content/CD_HPE
[ ]
Run Supervised Model
[ ]
Run Distillation Model
[ ]
0s completed at 11:39 PM

SCAN ME

We are,

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Ashwin De Silva
Graduate Member (Tutor)
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