STUTTGART MEDIA UNIVERSITY

MASTER THESIS

Applied Research of an End-to-End Human Keypoint Detection Network with Figure Ice Skating as Application Scope

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A thesis submitted in fulfillment of the requirements for the degree

Master of Science

Computer Science and Media

April 27, 2020

Declaration of Authorship

I, Nadin-Katrin APEL, declare that this thesis titled, "Applied Research of an End-to-End Human Keypoint Detection Network with Figure Ice Skating as Application Scope" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at
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- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such
- quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was
- done by others and what I have contributed myself.

Signed:

_____

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_____

"Data is a precious thing and will last longer than the systems themselves."

Tim Berners-Lee

STUTTGART MEDIA UNIVERSITY

Abstract

Computer Science and Media

Master of Science

Applied Research of an End-to-End Human Keypoint Detection Network with Figure Ice Skating as Application Scope

by Nadin-Katrin APEL

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

Acknowledgements

The acknowledgments and the people to thank go here, don't forget to include your project advisor laser. . . laser

Contents

Acronyms

bl layer **L** with largest feature maps. xi, 5

laser A strange animal, not to be confused with. ix

List of Figures

List of Tables

List of Abbreviations

LAH	**L**ist **A**bbreviations **H**ere
WSF	**W**hat (it) **S**tands **F**or

Physical Constants

Speed of Light $\quad c_0 = 2.997\,924\,58 \times 10^8\,\mathrm{m\,s^{-1}}$ (exact)

List of Symbols

a	distance	m
P	power	W ($\mathrm{J\,s^{-1}}$)
ω	angular frequency	rad

For/Dedicated to/To my…

Chapter 1

Introduction

1.1 Motivation and Goals

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1.2 Related Work

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Chapter 2

Figure Skating Pose Detection

2.1 Complexity of Figures

- existing KP detectors struggle (OpenPose, VideoPose)

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2.2 Distinct Rating System

- human struggle as well -> rating system with points, many abstractions, still often experienced as not fair

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Chapter 3

Dataset

3.1 Synthetic Dataset: 3DPeople

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3.2 Data Processing

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Chapter 4

Method

4.1 Network Architecture

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4.1.1 Body Part Detection Module

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4.1.2 Joint Detection Module

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4.2 Training Performance

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4.3 Inference Runtime Analysis

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4.4 Implementation Details

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Chapter 5

Experiments

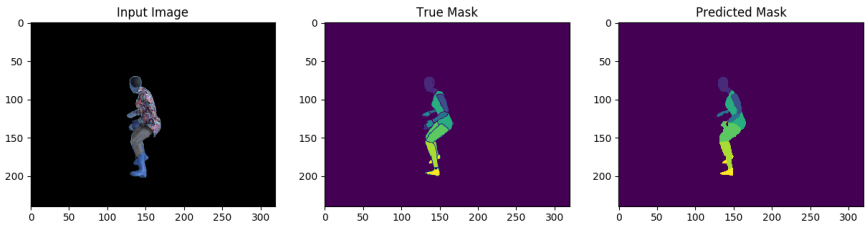

FIGURE 5.1: Predicted mask after 3845th epoch with custom loss function and Adam optimizer_kps

5.1 Ablation Study

5.1.1 Body Parts Module

Stride-down, -up convolution before bl

MobileNet extended with UNet

MobileNet extended with HRNet

Experiment with concat and add layers

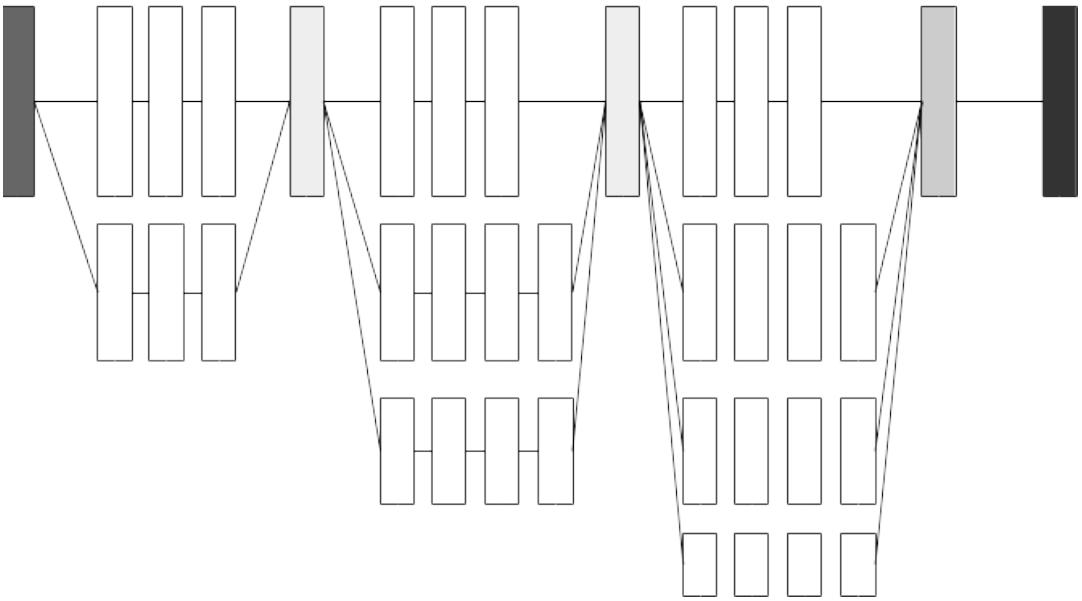

FIGURE 5.2: HRNet v7.

Best performing network HRNet v7

5.1.2 Joint Module

Dense Modules

Fully Convolutional

5.2 Comparison of Optimizer Algorithms

- Adam
- Nadam
- SGD

  constant learning rate

  Constant decreasing learning rate

  Constant decreasing learning rate with reset of learning rate on plateau

  Increasing decreasing learning rate on plateau

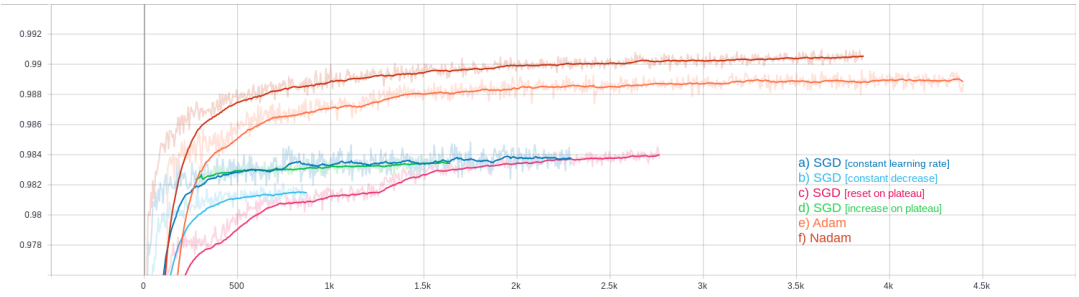

FIGURE 5.3: Accuracy

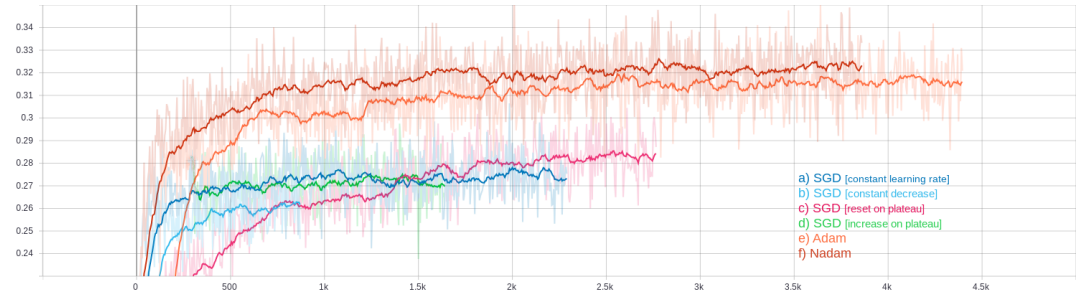

FIGURE 5.4: Correct body part pixel relation

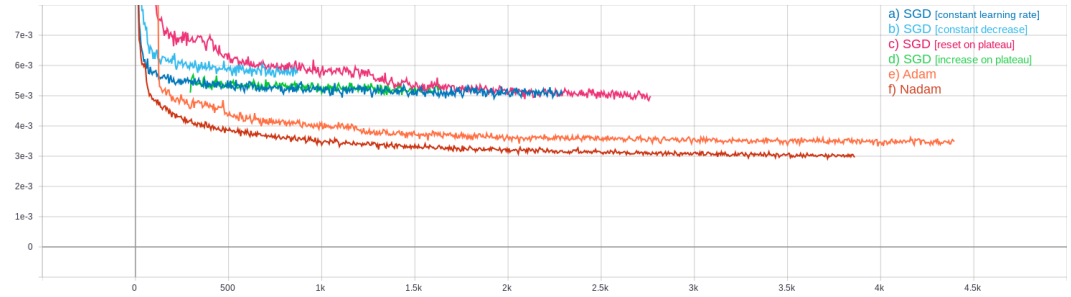

FIGURE 5.5: Loss

Comparison of Adam, Nadam and SGD

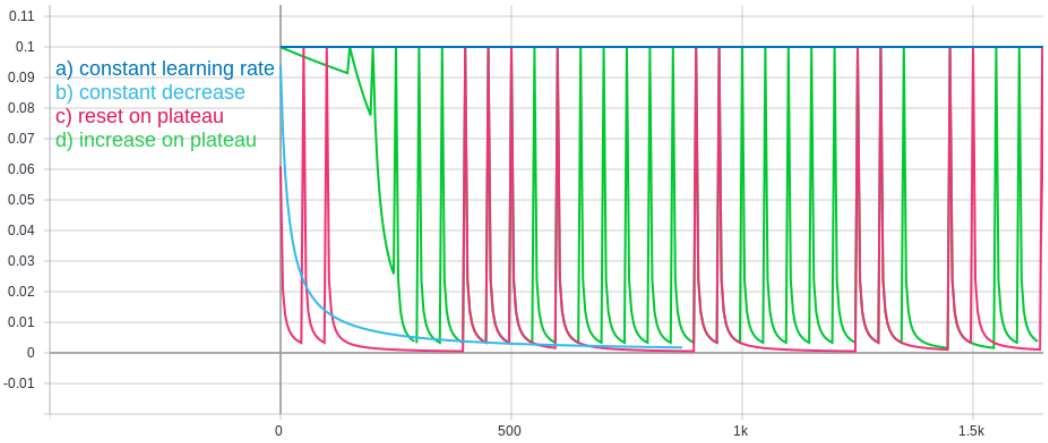

FIGURE 5.6: Learning Rate SGD.

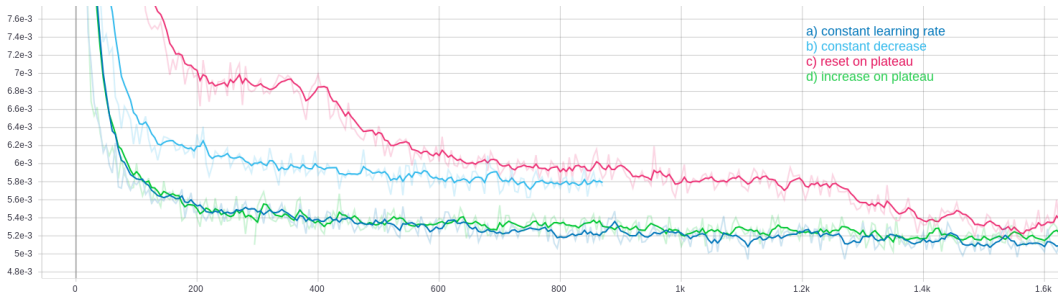

FIGURE 5.7: Loss SGD.

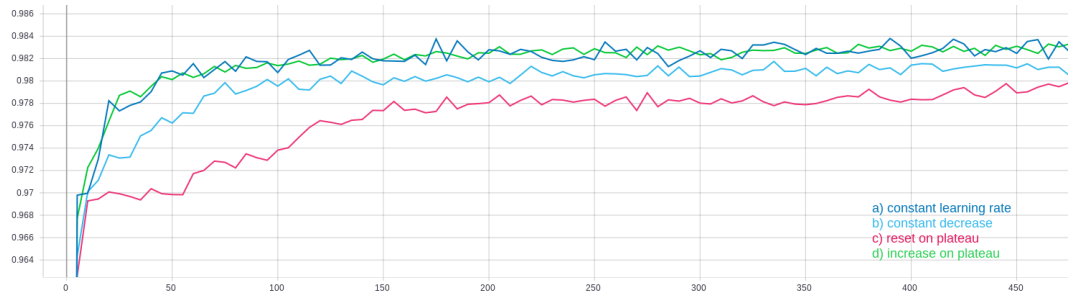

FIGURE 5.8: Accuracy SGD.

Experiments with SGD

5.3 Performance of loss functions

All performance measures are conducted on the Nadam optimizer_kps with the HR-Net for body part recognition from Recognition of body parts 5.1.1

5.3.1 Sparse Categorical Cross Entropy

5.3.2 Mean Squared Error

5.3.3 Our custom loss function CILoss

This loss function confronts the problem of class imbalance, which especially occurs in body part recognition. The background pixels appear most often, and the different body part classes occur by far less often and event they differentiate a lot in their relative occurrence.

We try to confront this problem with a weighed map, which takes the body parts as a graph and calculates the distances from each body part b_x to all other body parts b_n, and stores this data inside a table.

Additionally this weight map is evened out with a multiplier to reduce the distances and facilitate the learning process for the network.

$$\theta = y_t(x) - y_p(x)$$

$$\delta = \theta * \mu[argmax(y_t)]$$

$$L = \sum_{i=0}^{n} \theta_i + \delta_i$$

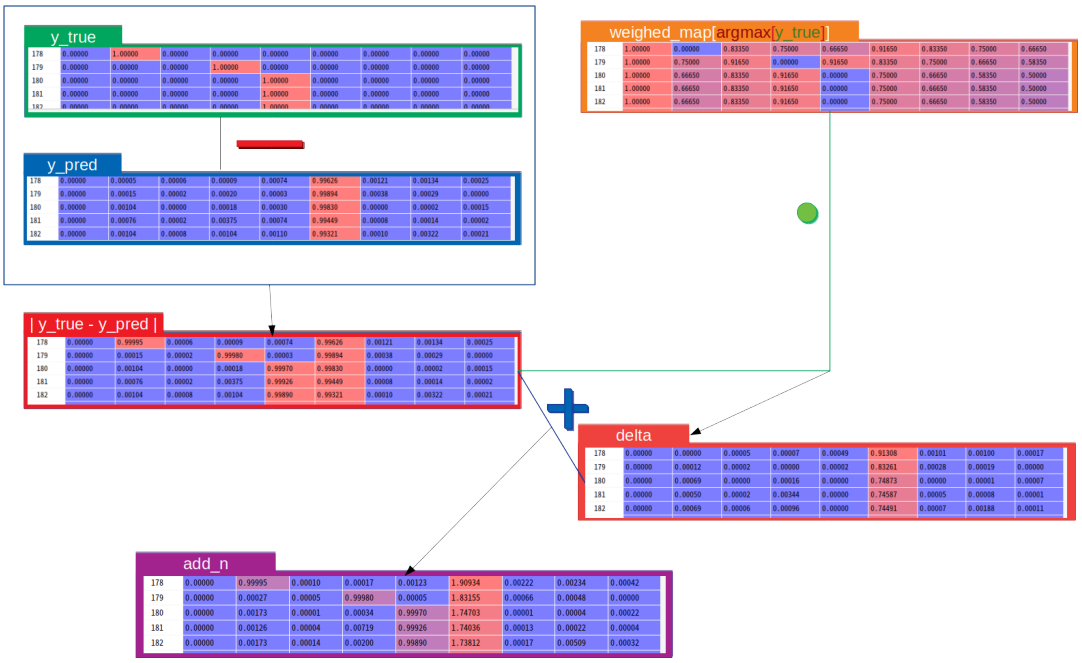

FIGURE 5.9: Visualization of custom loss calculation

Chapter 6

Conclusion and future thoughts