DeepSquat: Analyzing Weightlifting Form with Deep Learning

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Introduction

- Personal training is a $10 billion industry. Over the past 5 years, revenue for the Personal Training industry has increased at an annualized rate of ~1.9%, to $9.1 billion.

- Growth of the industry is largely fueled by an underlying worsening obesity trend. However, due to the high prices of personal training, populations such as students, and mid- to low-income earners are seldom able to afford personal training, which partly explains the correlation between poverty and obesity.

- In our project, we built a deep learning model to analyze people's squat forms so that personal training can be made more accessible to less financially well-off individuals.
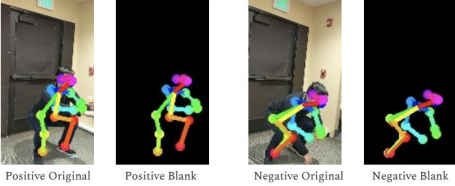
Dataset

- Recorded 13 people doing 219 squats.
- Manually labeled the data.
- 109 good form (positive); 110 bad form (negative).
- Generated 9492 individual images from the videos.
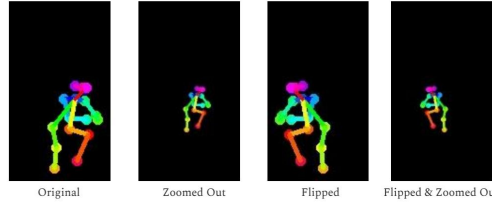- 8544 training data (90%); 440 val data (5%); 440 test data (5%).

Age Breakdown

Gender Breakdown
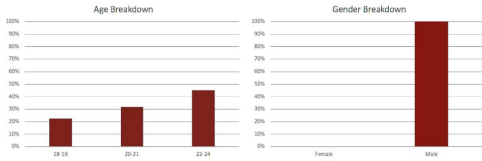
Pose Analysis

- Used tf-pose (https://github.com/ildoonet/tf-pose-estimation) for pose estimation.
- Tested pose on both original image and blank image.

Positive Original

Positive Blank

Negative Original

Negative Blank

Data Augmentation

Original

Zoomed Out

Flipped

Flipped & Zoomed Out
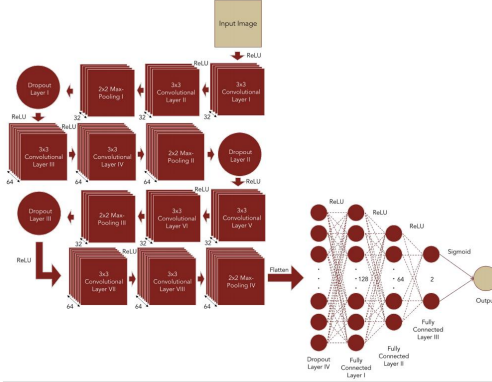
Algorithms and Models

Architecture

Experiments

Number of Conv-Conv-MaxPool-Dropout layers	L2 regularization parameter					
	0.01		0.001		0.0001	
	Train Loss	Eval Loss	Train Loss	Eval Loss	Train Loss	Eval Loss
1	2.21	3.54	0.31	2.01	0.04	1.36
2	3.62	4.75	0.46	1.38	0.07	1.12
3	5.25	5.38	0.65	0.94	0.26	0.4
4	5.10	5.25	0.82	0.95	0.35	0.49

Kernel Size in Convolutional Layer	L2 regularization parameter					
	0.0001		0.00001		0.000001	
	Train Loss	Eval Loss	Train Loss	Eval Loss	Train Loss	Eval Loss
2 * 2	0.05	1.91	0.01	1.82	0.002	1.84
3 * 3	0.05	2.00	0.007	1.94	0.002	1.97
4 * 4	0.05	1.83	0.008	1.83	0.003	1.97

Results & Analysis

Results

model accuracy

model loss
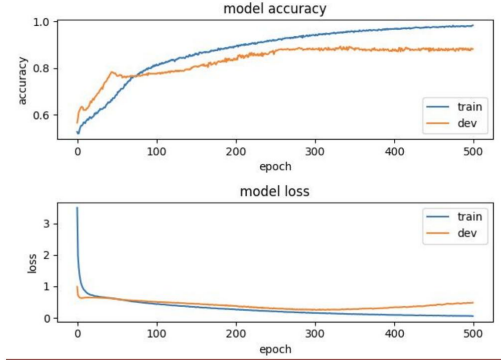
Training Loss	Training Accuracy	Eval Loss	Eval Accuracy	Test Loss	Test Accuracy
0.05	98.36%	0.48	88.18%	0.32	91.59%

Discussion

- Our CNN with 4 Conv-Conv-MaxPool-Dropout layers is complicated enough to understand the features we use and also generalize well on the dev set
- Future Projects: data quality and quantity can be improved
    - Quality: some negative data veer toward the extremes of bad form; reality more nuanced.
    - Quantity: more data; different genders, physique, weight used for the squats
- Idea can be expanded to more exercises to build a more complete AI Personal Trainer

References

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