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Deep Learning Final Project (Revised):
NFL Football Player Injury Prediction and Prevention using Neural Networks

Project Category: Football Player Injury Prediction and Prevention

Motivation:

For this class project, our goal is to build a model that detects key points identifying human body joints in order to ultimately prevent the number of waist-down related injuries experienced by National Football League (NFL) players on the field - this can help address the NFL's top priority of advancing athlete health/safety and performance. We plan to use deep learning frameworks to develop a model for waist-down joint detection. We believe neural networks are appropriate for this problem because "the multifactorial complex nature of sports injuries arise not from the linear interaction between isolated and predictive factors, but from the complex interaction among a web of determinants" (Bittencourt et al., 2016). Moreover, multiple academic papers have used deep learning methods like Faster R-CNN and DeepPose for key-point detection and pose estimation. We will use publicly available videos of football game highlights and a data annotation system called LabelBox to manually create key-point annotations of football players. Specifically, we will mark the location of waist-down joints including hips, knees, ankles, and toes to produce the dataset. We intend to annotate roughly 10 frames per second of video footage, which should provide enough training and testing data to build and evaluate a machine learning model. Our preliminary results will be an application of a neural network architecture to better predict and reduce lower extremity injuries faced by football players on the field. Although the full project extends beyond the scope of this course, we hope to contribute to the goal of improving athlete safety and performance.

Dataset:
- Football Videos (YouTube) - https://www.youtube.com/results?search_query=nfl+highlights
- Football Videos (Kaggle) - https://www.kaggle.com/c/nfl-impact-detection/overview

Note: the NFL cannot provide us with data due to issues surrounding player privacy and intellectual property, but the YouTube and Kaggle data sources are good alternatives (the Kaggle dataset in particular is very similar to the videos produced by the NFL).

Literature Review/ Related Work:
- DeepPose: Human Pose Estimation via Deep Neural Networks (2014) - https://openaccess.thecvf.com/content_cvpr_2014/papers/Toshev_DeepPose_Human_Pose_2014_CVPR_paper.pdf
- Joint Detection with Faster R-CNN (2016) - https://www.researchgate.net/publication/318900171_Joint_Detection_with_Faster_R-CNN

- Refining Joint Locations for Human Pose Tracking in Sports Videos - https://openaccess.thecvf.com/content_CVPRW_2019/papers/CVSports/Zecha_Refining _Joint_Locations_for_Human_Pose_Tracking_in_Sports_Videos_CVPRW_2019_paper.p df
- NFL and AWS Partner to Transform Player Health & Safety (2019) - https://static.www.nfl.com/image/upload/v1617129736/league/exytxzlvsjsyimpbgs9u.pdf
- Data scientists are predicting sports injuries with an algorithm (Nature, 2021) - https://www.nature.com/articles/d41586-021-00818-1
- Secure prediction and assessment of sports injuries using deep learning based convolutional neural network (2021) - https://link.springer.com/article/10.1007/s12652-020-02560-4
- Complex systems approach for sports injuries: moving from risk factor identification to injury pattern recognition - narrative review and new concept (2016) - https://bjsm.bmj.com/content/50/21/1309.citation-tools

Intended Experiments:
Our plan is to build and evaluate a neural network to identify NFL football player waist-down joints. Once we generate the data through key-point video annotation, we will create train, validation, and test datasets. We can use pre-trained network architectures for localization and pattern detection (e.g. R-CNN and DeepPose) to create our own neural network. Our strategy is to start with a simple model and build up its complexity based on accuracy and loss metrics. We can also tune the parameters and tweak the network structure to produce the best performing model. Perhaps we can compare the performance of our model to that of the other team who is working on the same overarching project.