Master Research Proposal   Nr:

XXXX

Topic: **A Mobile-Optimized Deep Learning Pipeline for Automated Real-Time Golf Swing Plane Feedback**

Swing plane analysis is a fundamental component in golf instruction. Coaches and players traditionally rely on video recordings and dedicated applications that require manual drawing of reference lines to evaluate whether a swing is "on-plane," "over-the-top," or "under-plane" [1]. This process is labor-intensive, requires domain knowledge, and crucially, offers no real-time feedback [2]. While commercial systems using wearable sensors (like IMUs) or sophisticated launch monitors provide valuable data [3], they require the purchase of specialized, often costly, equipment that many golfers are hesitant to adopt [4,5]. Furthermore, these systems often focus on club/hand path derived from sensors or impact-centric parameters, and do not typically offer real-time feedback from video alone.

Fortunately, the increasing processing power and camera quality of modern smartphones create new possibilities for mobile swing analysis, without the use of additional sensors. Academic work has already started exploring this potential specifically for golf swing analysis, utilizing computer vision (CV) and deep learning (DL) methods like pose estimation and object detection [6], often with the goal of marker less analysis on mobile devices. However, a gap remains in leveraging this mobile technology to create a system that integrates these techniques to automatically provide immediate, actionable swingplane feedback without requiring additional sensors or manual setup.

This thesis aims to bridge this gap by developing and evaluating a CV/DL pipeline optimized for mobile execution, enabling fully automated, real-time swing plane analysis using only the smartphone's camera.

The proposed work consists of the following parts:

1. **Literature Review:** A comprehensive analysis of scientific literature, commercial products, and patents will establish the context. This includes examining biomechanics , CV/DL in golf, swing plane definitions, and real-time feedback methods.
2. **Data Acquisition:** A custom dataset of roughly 5000 manually labeled video frames (approx. 40 Videos) with clubhead bounding boxes will be created for training the object detection model. Video data will be webscraped from various free online sources.
3. **Model Development & Implementation:** A pipeline will be designed and trained, in- cluding a pose estimation model for anatomical keypoints (shoulders/elbows) to define the swing plane and an object detection model for clubhead tracking, trained on the custom dataset. The implementation will also include the coaching feedback logic.
4. **iOS Application Prototype Development:** The models and logic will be integrated into a functional iOS prototype. This involves model optimization for mobile execution, implementing the real-time video processing pipeline, and designing the UI for immediate visual feedback.
5. **System Evaluation:** The iOS prototype's real-time performance will be evaluated in a small field study (single participant), focusing on tracking accuracy, correct plane classification (on-plane, over, under), and achieving 60 FPS on target mobile hardware.

The thesis will contain a detailed description of all developed and used algorithms as well as a profound result evaluation and discussion. The implemented code will be documented and provided. Extended research on literature, existing patents, and related work in the corresponding areas will be performed.

Advisors: Prof. Dr. Bjoern Eskofier *(Machine Learning and Data Analytics Lab, FAU Erlangen-Nürnberg)*

Master Research Proposal Nr:

XXXX

Student: Sebastian Hoefler (MatrNr. 22591879)
Start—End: 01.12.2024 - 30.05.2025

References

[1] Bourgain, M., Rouch, P., Rouillon, O., Thoreux, P., & Sauret, C. (2022). Golf Swing Biomechanics: A Systematic Review and Methodological Recommendations for Kinematics. *Sports* (Basel, Switzerland), 10(6), 91 https://doi.org/10.3390/sports10060091

[2] Perini, E. (2023). Feasibility of Mobile Phone-Based 2D Human Pose Estimation for Golf : An analysis of the golf swing focusing on selected joint angles (Dissertation). Retrieved from https://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-329035

[3] Bishop, C., Wells, J., Ehlert, A., Turner, A., Coughlan, D., Sachs, N., & Murray, A. (2023). Trackman 4: Within and between-session reliability and inter-relationships of launch monitor metrics during indoor testing in high-level golfers. *Journal of Sports Sciences*, 41(23), 2138–2143. https://doi.org/10.1080/02640414.2024.2314864

[4] Arccos Golf. *Golf's #1 Game Tracker* (n.d.). Arccos Golf. Retrieved April 29, 2025, from https://eu.arccosgolf.com

[5] Hackmotion Golf Swing Analyzer & Wrist Angle Training Aid (n.d.). Hackmotion. Retrieved April 29, 2025, from https://hackmotion.com

[6] McNally, W., Vats, K., Pinto, T., Dulhanty, C., McPhee, J., & Wong, A. (2019). GolfDB: A video database for golf swing sequencing. *IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), 2553–2562*. https://doi.org/10.1109/cvprw.2019.00311