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## Quantifying and Characterizing Punches in Elite Boxing Matches during an Official Competition

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### INTRODUCTION:

Quantifying and characterizing punches in boxing fights enables profiling athletes and study winning strategies [1]. Producing this data requires analyzing videos to detect punches and further characterize them. Automatically detecting punches from videos remains challenging, leaving this task to a tedious manual annotation. In collaboration with the French Federation for Boxing (FFB) in the context of an official competition, accelerometers from Inertial Measurement Units (IMU) strapped in the gloves have been tested to efficiently detect punches.

### METHODS:

FFB officers equipped every athlete with wireless IMU (Xsens Awinda, 120 Hz) before every fights. IMU were strapped on the distal part of the forearms at each hand, and protected under gloves. Punches were automatically identified as peaks detected in the acceleration. IMU were synchronized with high-resolution videos (Qualisys Miquis Video, HD 60 fps) to produce short sequences of animated images representing each punch. A manual annotation tool of these sequences was provided to video analysts of the FFB for the characterization of punches. Punches trajectories were labelled as miss", hit or blocked. Logistic regression analysis is used for establishing the potential associations between the fight result and the number of blocked, missed and hit punches.

### RESULTS:

A total of 21.474 punches over 94 × 3 minutes rounds (31 matches of 3 rounds, one match lasted 1 round only) has been detected. Analysts excluded 25.09% of false positives. We present results with respect to two different aspect: the efficiency of the annotation task and the athlete productions. Characterizing a punch required in average 7.16s [7.09, 7.23] (95% confidence intervals) for 11 annotators. We observed in average 144 [134, 154] punches towards the head and 22 [20, 24] towards the torso per round, with an average of respectively 56 [51, 62] and 13 [12, 15] successful hits, which agrees with results from the literature [2]. In the logistic regression, fight result is found to be significantly associated with both number of missed ( $p$ -value < 0.001, OR = 0.97 (0.94, 0.98)) and hit ( $p$ -value = 0.002, OR = 1.03 (1.01, 1.05)) punches but not with blocked punches ( $p$ -value = 0.913, OR = 1.00 (0.98, 1.09)).

### CONCLUSION:

Instrumenting boxers with IMU enables automatically identifying punches, saving precious manual annotation time that analysts can leverage to solely characterize hits. Better punch identification algorithms should likely reduce false-positives and save even more time. All characterization were performed over an accumulated time of 37.05 hours.

### References

- [1] P. Davis, et al, Amateur Boxing: Activity Profile of Winners and Losers, International Journal of Sports Physiology and Performance (2013).
- [2] M. Slimani, et al, Performance Aspects and Physiological Responses in Male Amateur Boxing Competitions: A Brief Review, Journal of Strength and Conditioning Research (2017).

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