DISC GOLF TRAJECTORY MODELLING COMBINING COMPUTATIONAL FLUID DYNAMICS AND RIGID BODY DYNAMICS

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Disc golf is arguably the sport with the broadest range of projectile shapes. Compared to other sports where only a single projectile is used, a typical disc golf athlete will carry more than twenty discs for a single competition. The choice of disc depends on the distance to the target, obstacles on the way to the target and wind conditions. Computational methods have the potential to consistently characterize the flight of a disc and lead to greater understanding of disc flight, and thereby contribute to both training and disc development.

This work combines computational fluid dynamics (CFD) simulations to obtain the aerodynamics properties of a disc with rigid body dynamics to simulate the actual flight. The CFD is based on steady-state simulations of non-rotating discs with a k-omega SST turbulence model. An unstructured mesh is used with 20 million cells and prism layers near the disc with first layer height of 10 µm. The geometry models are obtained using an Artec Eva 3D scanner followed by a spline reconstruction in CAD software. The aerodynamic properties are fed into a rigid body dynamics model based on [1], which is implemented in the open source projectile simulator Shot Shaper [2], developed by the author.

Fig. 1 (a) shows a comparison of lift/drag ratio (aerodynamic efficiency) for two different discs, a distance driver (DD) and a control driver (CD). Also included are results from wind tunnel experiments performed in [3], showing good agreement with the CFD simulation results. Fig. 1 (b) shows the flow pattern and pressure coefficient for the two discs for 2° angle of attack. The distance driver has a longer and thinner rim, leading to lower pressure underneath the rim (lower drag) and lower pressure on top of the disc (higher lift). Both these effects contribute to higher aerodynamic efficiency.

Fig. 2 (a) shows a comparison of the coefficient of moments for two control drivers with similar aerodynamic efficiency. The difference in moments indicate a difference in flight stability. Fig. 2(b) shows the simulated trajectory path for the discs, also including the distance driver, for a shot with release speed 21 m/s,

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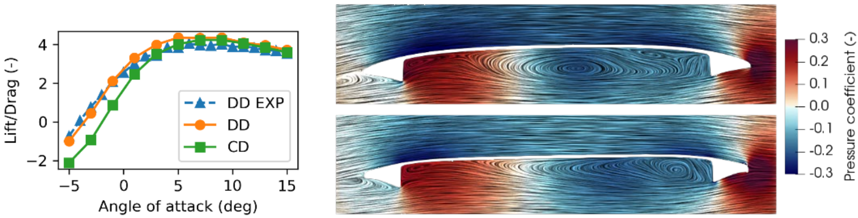
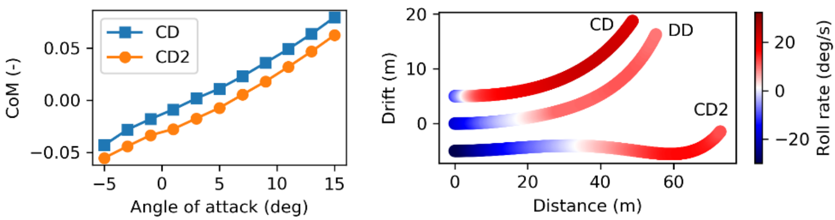
angular speed 156 rad/s, pitch angle 10° and roll angle 18°. The high stability disc (CD) will maintain the initial roll angle throughout the flight resulting in a long drift to the left. The low stability disc (CD2) has a more complex flight patterns where it first rolls over and drifts towards the right before ending with a drift to the left, resulting in an overall straighter flight. The DD flight is similar to the CD, despite a lower roll rate. Due to the relatively low release speed, the disc does not roll sufficiently to the right to get a similar flight pattern as CD2, resulting in less distance despite the higher aerodynamic efficiency. This serves as an example on how the proposed approach can contribute to the analysis of disc golf throws.



(a) (b)

Fig. 1: Aerodynamic efficiency, (a) Lift/drag curves, (b) Flow pattern (flow from right to left) and pressure coefficient in a slice through the disc center for DD (top) and CD (bottom).



(a) (b)

Fig. 2: Trajectory modelling, (a) Coefficient of moments for two different control drivers, (b) Trajectories seen from above for the three discs considered, colored by roll rate.

1. Crowther WJ, Potts JR (2007) Simulation of a spinstabilised sports disc. Sports Eng 10.1: 3-21.
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