OPTIMISED CAMERA SETUP TO MINIMISE MEASUREMENT ERROR A PRIORI

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INTRODUCTION

Although motion capture systems are broadly applied, only little attention has been given to an a priori optimisation of the camera setup. Usually, cameras are placed by trial and error, which can be very time consuming especially for huge systems and camera fixation points which are difficult to reach. One main criterion considered during the setup postulates that as many points as possible within a predefined tracking volume are seen by at least two cameras. In theory, it would be sufficient to fulfill this criterion to determine the 3D-coordinates of a point in space; accordingly, this criterion has already been used to calculate an a priori optimised camera setup [1]. In reality, however, also the measurement error of the coordinates should be small. To minimise this error a priori, the angles between the optical axes of the cameras should be 90 degrees [2]. Considering this additional criterion, we present a new algorithm to optimise a priori a camera setup. The feasibility of the algorithm will firstly be proven in a virtual rowing scenario. Feasibility of the algorithm will encourage integration of further criterions which may finally prevent placing cameras by trial and error.

METHODS

Our constraints for the camera setup consist of the available fixation points for the cameras, the orientation of the cameras, and the angle of aperture of each camera. The cost function of the algorithm is based on the sum of maximal local measurement errors. In case that not every point of the predefined measurement volume is seen by at least two cameras, the cost function is infinity. Otherwise, the cost function can be explained as the sum over the maximal undetectable movement at each measurement point. The maximal undetectable movement is a function of the camera pixel size, camera distance to the measure point of interest, and camera angle of aperture. Knowing these parameters allows to define a square pyramidal cone for all cameras, i.e. pixels seeing the point. The intersection of two or more cones results in a polyhedron within which motion cannot be detected. By calculating the maximal distance between the vertices of the polyhedron, the maximal undetectable movement is determined at the corresponding measure point (Figure 1).

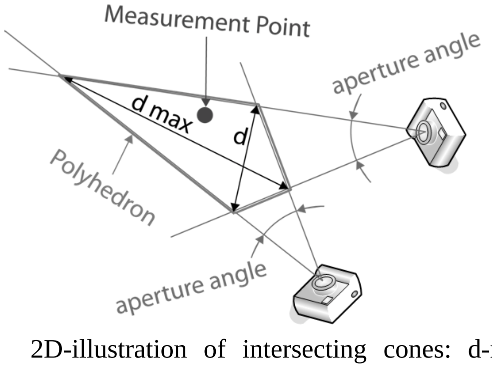

Figure 1: 2D-illustration of intersecting cones: d-max represents the maximal undetectable movement.

The algorithm was first applied on an existing virtual rowing scenario realised in our Cave [3]. The Cave is surrounded by a frame on which cameras can be mounted, i.e. the frame constrains camera positions. During the task, the rower moves within a well-defined volume. Like the frame, this volume was represented by discrete points. Since the visual line of each camera pointed through the centre of the measurement volume, the camera orientation was constrained. The camera angle of aperture was 40° which resulted, in combination with a camera resolution of two megapixels, in an angle of aperture of 0.0283° per pixel. To prove feasibility, the algorithm was applied on different numbers of cameras. It was hypothised that the more cameras are used, the smaller the maximal local measurement error will be.

RESULTS AND DISCUSSION

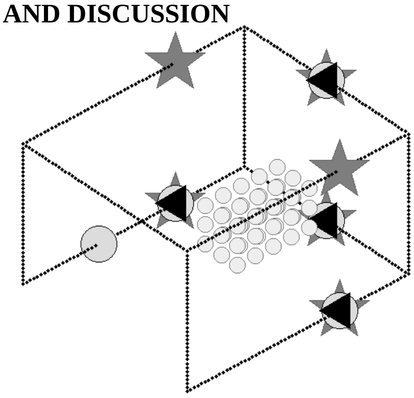

Figure 2: Illustration of the optimised setup of four (triangles), five (circles), and six (stars) cameras for a given measurement volume (small circles).

The camera setup corresponds partly to intuiteve solutions (Figure 2). As expected, the maximal local measurement error decreases due to implementation of more cameras (0.47 mm for two cameras, 0.30mm for three, and 0.28mm for four, 0.26mm for five, 0.25mm for six and seven cameras). However, using more than six cameras does not reduce the error but will contribute to avoid marker occlusion.

CONCLUSIONS

A new algorithm has been successfully applied to optimise the camera setup a priori under consideration of a maximal local measurement error. Implementing further constraints such as obstacles in the measurement volume or quite specific descriptions of segments to track including redundant markers, which may compensate for marker occlusion, may finally prevent placing the cameras by trial and error.

REFERENCES

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