Pool-Predictor - a Kalman-Filter Implementation

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Feburary 2020

In this article we're discussing an implementation of a Kalman-Filter to filter and predict the movement of balls on a pool table. We discuss the reasoning why we implemented the filter as a constant velocity model and its weak points in this situation. Since the performance of the filter deteriorates in cases of a rapid change in direction we developed two different implementations with adaptive behaviour. The implementations were tested in a simulator and with real world video footage of a pool table. In the end we compared the performaces of each filter to another.

1 Introduction

1.1 Game of Pool

At first glance the game of pool is very suitable to examine the behaviour of a kalman-filter [1] enhanced tracking system based on pure visual tracking. The surface of a pool table is made of a thin fabric which covers a hard surface i.e. slate or granite. The balls nowadays are usually made out of resin. This combination of materials creates very small rolling resistance and the balls behave almost fully elastic on collision. Also with only 2 DOF[1] a basic kalman filter implementation is fairly simple in this regard. But when two balls hit each other or a boundary, the velocity vector changes its orientation instantly. If this isn't taken into account, the filter needs some time to adapt to the new direction of movement and will produce wrong estimations during this time.

1.2 Visual Recognition of moving elements

1.3 Kalman-Filter

CVM

CAM

2 Related Work

R E Kalman: https://asmedigitalcollection.asme.org/fluidsc abstract/82/1/35/397706

Soccer Ball Tracking with prediction (velocity vector of player to presume ball velocity vector) Jong-Yun Kim, et al https://ieeexplore.ieee.org/abstract/document/5298809

Trajectory of a Billiard Ball and Recovery of Its Initial Velocities Yan-Bin Jia, et al http://web.cs.iastate.edu/ jia/papers/billiard-analysis.pdf

Visual Tracking with kalman filter Shiuh-KuWeng et al https://www.sciencedirect.com/science/artic

Tracking and Prediction using Markov-Models Mathieu Salzmann ; Raquel Urtasun https://ieeexplore.ieee.org/abstract/document/612648

Adaptive Kalman Filtering for INS/GPS (uses filterbanks and innovation based but for very confined situation) A. H. MohamedK. P. Schwarz https://link.springer.com/article/10.1007/s001900050236

On the identification of variances and adaptive Kalman filtering (our Approach to dynamic filtering but only steady state) R. Mehra https://ieeexplore.ieee.org/abstract/document/1099422

[1] dimensions of freedom

Recursive Noise Adaptive Kalman Filtering by Variational Bayesian Approximations Simo Sarkka ; Aapo Nummenmaa https://ieeexplore.ieee.org/abstract/document/4790261

3 Implementation

3.1 differences between implementations

3.2 CVM devel + Problems in Prediction

3.3 Dyn CVM devel

3.4 Smart Devel

4 Simulations

4.1 Structure of Simulation

optimal parameters

4.2 Sampling

4.3 Noise

4.4 Velocity

5 Results

5.1 Real Video - Prediction vs. Filtered

No Ground Truth

5.2 CVM vs. CAM

6 Future Work

7 Improvements

Abstand von Bande durch diskrete abtastung ungenau, weil zeitliche unschärfe entsteht (abprall zwischen zwei frames). Prediction müsste unabhängig von frames gemacht werden.

7.1 AR App for Training

7.2 Broadcasting

8 Acknowledgement

T.Edeler wegen Vorlesung diesdas.

References

[1] R. E. Kalman, "A new approach to linear filtering and prediction problems," *Journal of Basic Engineering*, 1960.