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| Extended Kalman Filter |
| **Preparation of Camera-Ready Contributions to SCITEPRESS Proceedings** |
| Peter Ambühl1, Yannik Kübli1 and Timo Sieber1 |
| 1Bern University of Applied Sciences, Jlcoweg 1, Burgdorf, Switzerland  {peter.ambuehl, yannik.kuebli, timo.sieber}@students.bfh.ch |

Keywords: Attitude Determination, Extended Kalman Filter,

Abstract: Kalman filter is still a popular topic for research even after its history of half-century and many papers have been published. Most of them are about new application of the filter. Since the standard Kalman filter is only for linear systems, there are also a lot of papers for applying filter to a nonlinear system – the Extended Kalman Filter (EKF). Most of the systems around us are nonlinear. This subject was treated already in the beginning of Kalman filter. Our application is to estimate the attitude of an aircraft by applying EKF. Therefore we recorded a data set with six different static states and developed an algorithm for a correct estimation.

# 1 INTRODUCTION

The attitude of an aircraft can be defined as the relationship between the aircraft and the earth frame, it is usually described with the three ‘Euler angles’ roll (side to side tilt), pitch (fore and aft tilt) and yaw. The yaw (nose left or right) angle is not used for the evaluation of the horizontal attitude. The attitude is not only used as a visual indicator by the pilot, but also as a reference for the autopilot. Therefore, it needs to be evaluated fast and correctly, also in non-steady situations.

The Kalman filter is a recursive filter. With a series of measurements containing noise a statistically optimal estimate of the underlying system can be produced.

By using the Kalman Filter, an adequate system model has to be designed. If the linear Kalman filter is used, the system is defined as linear from the beginning. By applying the linearized Kalman filter, the system input is nonlinear, but the input data will be linearized. For nonlinear applications, the Extended Kalman filter (EKF) was developed. It is probably the most used type for the aircraft attitude problem. However, it is only reliable for systems which are almost linear and the Jacobian matrices are hard to obtain. Theses issuses came up, because its use of linearization. To improve this issue, the unscented Kalman filter (UKF) was proposed. For the UKF, three scalar scaling parameters are necessary. However, the Central Difference Kalman filter (CDKF) only uses one parameter, therefore it can get better performance.

# 2 Methods

**2.1 Data Base**

To get a realistic data base, the output of a gyro and an accelerator sensor of a commercial smartphone were recorded. After a specific order, the sensor events were triggered. Start position was the phone lying on a table with the display on top. Then, the following order was proceeded:

side tilt +90°s → StartPos. → side tilt -90° → StartPos. → fore tilt +90° → StartPos. → aft tilt -90° → StartPos. → nose left → StartPos. → nose right.

Every state remains for two seconds.

**2.2 Concept**

First, we will run the data of the accelerator sensor over a simple 1st order low pass filter.

In a second step, the Extended Kalman Filter is implemented in MatlabWeighting is adjusted at every step

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Example:

|  |  |
| --- | --- |
| a = b + c | (1) |

**2.3.7 Program Code**

Program listing or program commands in text should be set in typewriter form such as Courier New.

Example of a Computer Program in Pascal:

begin

Writeln('Hello World!!');

End.

The text must be aligned to the left with the linespace set to single and in 9-point type.

**2.3.8 Reference Text and Citations**

References and citations should follow the Harvard (Autor, date) System Convention (see the References section). As example you may consider the citation (Smith, 1998). Besides that, all references should be cited in the text. No numbers with or without brackets should be used to cite or to list the references.

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**References**

**Kim, Phil. 2010.** *Kalman Filter for Beginners.* Republic of Korea : A-JIN Publishing company, 2010.

**Ping Han, Haoliang Gan, Weikun He.** *Aircraft Attitude Estimation Based on Central.* Tianjin, P.R. China : Tianjin Key Lab for Advanced Signal Processing, Civil Aviation University of China, CAUC,.