CZECH TECHNICAL
UNIVERSITY
IN PRAGUE

F3

Faculty of Electrical Engineering
Department of Control Engineering

Master's Thesis

Indoor localization system for automated vehicles based on Ultra-Wideband technology

Bc. Jitka Hodná
Cybernetics and robotics

May 2021

Datavision s. r. o.
Supervisor: Ing. Tomáš Novák

MASTER'S THESIS ASSIGNMENT

I. Personal and study details

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Branch of study: **Cybernetics and Robotics**

II. Master's thesis details

Master's thesis title in English:

Indoor localization system for automated vehicles based on Ultra-Wideband technology

Master's thesis title in Czech:

Interiérový lokalizační systém pro autonomní prostředky s využitím technologie Ultra-Wideband

Guidelines:

1. Study the state of the art data fusion principles used for pose estimation. Study principles of Inertial navigation systems (INS)
2. Propose a localization system for autonomous vehicles based on fusion of data from Ultra-Wideband (UWB) positioning system and on-board dead-reckoning sensors such as Inertial measurement unit (IMU)
3. Evaluate proposed localization system for use in industrial environments.

Bibliography / sources:

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[2] GREWAL, MOHINDER S., ANGUS P. ANDREWS, AND CHRIS G. BARTONE - GLOBAL NAVIGATION SATELLITE SYSTEMS, INERTIAL NAVIGATION, AND INTEGRATION - John Wiley & Sons, 2020
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[4] MOORE, THOMAS, AND DANIEL STOUCH - A GENERALIZED EXTENDED KALMAN FILTER IMPLEMENTATION FOR THE ROBOT OPERATING SYSTEM, Intelligent autonomous systems 13. Springer, Cham, 2016. 335-348
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[6] LI, JIAXIN, ET AL. - ACCURATE 3D LOCALIZATION FOR MAV SWARMS BY UWB AND IMU FUSION, 2018 IEEE 14th International Conference on Control and Automation (ICCA). IEEE, 2018.

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Date of master's thesis assignment: **15.01.2021** Deadline for master's thesis submission: _____

Assignment valid until:
by the end of summer semester 2021/2022

Ing. Tomáš Novák	prof. Ing. Michael Šebek, DrSc.	prof. Mgr. Petr Páta, Ph.D.
Supervisor's signature	Head of department's signature	Dean's signature

Acknowledgement / Declaration

Lorem ipsum sit amet, thanks to TACR (TACR project with the correct name and number)

I hereby declare that I wrote the presented thesis on my own and that I cited all the used information sources in compliance with the Methodical instructions about the ethical principles for writing an academic thesis.

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Prague, May 21, 2021

Abstrakt / Abstract

Lorem ipsum sit amet

Klíčová slova: ultra-wideband, imu, ins, localization, indoor, kalman-filtr, ekf

Překlad titulu: Interiérový lokalizační systém pro autonomní prostředky s využitím technologie Ultra-Wideband

The most awesome abstract

Keywords: ultra-wideband, imu, ins, localization, indoor, kalman-filter, ekf

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Chapter 1
Experiments

1.1 Used hardware description

1.1.1 Sensors specification

Inertial measurement unit used during experiments is Epson M-G365PDF1 (loaner sample). Epson M-G365 is used in a number of various applications ranging from stabilization systems (as camera gimbal) or navigation systems.

Figure 1.1. IMU used in experiments Epson M-G365PDF1[??]

The IMU has six degrees of freedom and measures angular rates and linear accelerations in three axis. It is factory calibrated and the calibration data are stored in the memory of the unit. Technical specifications of Epson M-G365 can be found at 1, while summary is included in Table 1.1

Specification	Value
Triple gyroscopes	± 450 °/sec
Gyroscopes bias instability	1.2 °/hr
Gyroscopes initial bias error	0.1 °/s
Angular random walk	0.08 °/√hr
Tri-axis accelerometers	± 10 G
Accelerometers bias instability	16 μ G
Accelerometers initial bias error	3 mG
Velocity random walk	0.033 (m/s)/√hr

Table 1.1. Technical specifications of Epson M-G365PDF1[??].

1 Datasheet of Epson M-G365 `https://global.epson.com/products_and_drivers/sensing_system/download_hidden/pdf/m-g365pd_datasheet_e_rev20201007.pdf`

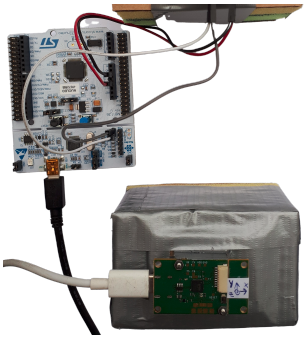

Figure 1.2. Experimental setup for static data acquisition of Epson M-G365PDF1.

As I already mentioned in Chapter ??, the AVAR analysis of IMU sensors can give us a brief overview of IMU's specification. Experimental setup for static data acquisition can be seen in Figure 1.2. The sensor is mounted on two sponge and fixed with cartboard. The static data were recorded for 48 hours at frequency of 30.0 Hz.

For AVAR computation I used a python library named AllanTools, for purposes of this thesis the overlapping Allan deviation function is used. The result can be seen in Figures TODO!

1.1.2 CART2 platform and sensors mounting

1.2 Experimenty v BU04 mistnosti

1.2.1 Popsani experimentalniho setupu v BU04

1.2.2 Popsani provedeni experimentu (jake, jak se udelaly)

1.2.3 Zhodnoceni experimentu v BU04 (

1.3 Experimenty v CIIRC s VICONem

1.3.1 Popsani experimentalniho setupu v CIIRC

1.3.2 Popsani provedeni experimentu

1.3.3 Zhodnoceni experimentu v BU04