FH University of Applied Sciences TECHNIKUM WIEN

MASTER THESIS

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering at the University of Applied Sciences Technikum Wien - Degree Program Mechatronics/Robotics

Virtualisierung eines Echtzeit-Betriebssystems zur Steuerung eines Roboters mit Schwerpunkt auf die Einhaltung der Echtzeit

By: Halil Pamuk, BSc

Student Number: 51842568

Supervisor: Sebastian Rauh, MSc. BEng

Wien, March 26, 2024

Declaration

“As author and creator of this work to hand, I confirm with my signature knowledge of the relevant copyright regulations governed by higher education acts (see Urheberrechtsgesetz /Austrian copyright law as amended as well as the Statute on Studies Act Provisions / Examination Regulations of the UAS Technikum Wien as amended).

I hereby declare that I completed the present work independently and that any ideas, whether written by others or by myself, have been fully sourced and referenced. I am aware of any consequences I may face on the part of the degree program director if there should be evidence of missing autonomy and independence or evidence of any intent to fraudulently achieve a pass mark for this work (see Statute on Studies Act Provisions / Examination Regulations of the UAS Technikum Wien as amended).

I further declare that up to this date I have not published the work to hand nor have I presented it to another examination board in the same or similar form. I affirm that the version submitted matches the version in the upload tool.“

Wien, March 26, 2024 Signature

Kurzfassung

Erstellung einer Echtzeit-Robotersteuerungsplattform unter Verwendung von Salamander OS, Xenomai, QEMU und PCV-521 in der Yocto-Umgebung. Die Plattform basiert auf Salamander OS und nutzt Xenomai für Echtzeit- Funktionen. Dazu muss im ersten Schritt die Virtualisierungsplattform evaluiert werden. (QEMU, Hyper-V, Virtual Box, etc.) Als weiterer Schritt folgt die Anbindung eines Roboters über eine VARAN-Bus Schnittstelle. Das gesamte System wird in der Yocto-Umgebung erstellt und konfiguriert. Das Hauptziel der Arbeit ist es, herauszufinden, wie die Integration von Echtzeit-Funktionen und effizienten Kommunikationssystemen in eine Robotersteuerungsplattform die Reaktionszeit und Zuverlässigkeit von Roboteranwendungen verbessern kann

Schlagworte: Schlagwort1, Schlagwort2, Schlagwort3, Schlagwort4

Abstract

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

Keywords: Echtzeit, Virtualisierung, Xenomai, VARAN

Contents

1 Einleitung

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{i=n} x_i = \frac{x_1 + x_2 + \ldots + x_n}{n}$$

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

$$\int_0^\infty e^{-\alpha x^2}\mathrm{d}x = \frac{1}{2}\sqrt{\int_{-\infty}^{\infty} e^{-\alpha x^2}\mathrm{d}x \int_{-\infty}^{\infty} e^{-\alpha y^2}\mathrm{d}y} = \frac{1}{2}\sqrt{\frac{\pi}{\alpha}}$$

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

$$\sum_{k=0}^{\infty} a_0 q^k = \lim_{n\to\infty} \sum_{k=0}^{n} a_0 q^k = \lim_{n\to\infty} a_0 \frac{1-q^{n+1}}{1-q} = \frac{a_0}{1-q}$$

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font,

how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

$$x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-p \pm \sqrt{p^2 - 4q}}{2}$$

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

$$\frac{\partial^2 \Phi}{\partial x^2} + \frac{\partial^2 \Phi}{\partial y^2} + \frac{\partial^2 \Phi}{\partial z^2} = \frac{1}{c^2} \frac{\partial^2 \Phi}{\partial t^2}$$

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

1.1 Stand der Technik

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like “Huardest gefburn”? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

1.2 Problem- und Aufgabenstellung

In robotics, accurate and timely control is crucial to ensure precise movements and reliable interaction with the environment. However, existing robot control systems often have limitations in terms of real-time capabilities and communication efficiency, which can have a detrimental effect on response time and reliability. The challenge is to develop a powerful real-time robot control platform that overcomes these limitations and improves the performance of robotic applications.

1.3 Zielsetzung

The main objective of this work is to create a real-time robot control platform that integrates Salamander OS, Xenomai, QEMU and PCV-521 in the Yocto environment. By combining these technologies, a platform is to be created that provides real-time functions and efficient communication systems. This integration is expected to lead to a significant improvement in the response time and reliability of robot applications.

2 Methodik

The methodology of this thesis consists of several steps. First, a comprehensive literature review is conducted to understand the current trends and challenges in real-time robot control. Based on the literature study, a suitable virtualisation platform is selected. After the selection of the virtualisation platform, the robot control platform is implemented. This step includes the installation and configuration of Salamander OS, Xenomai, QEMU and PCV-521 in the Yocto environment. Once the platform has been implemented, the robot is connected via a VARAN bus interface. Finally, the platform is evaluated to determine how the integration of real-time functions and efficient communication systems improves the response time and reliability of robot applications.

- Evaluation der Virtualisierungsplattform: Ich werde verschiedene Virtualisierungsplattformen wie QEMU, Hyper-V, Virtual Box usw. evaluieren. Dies ist ein wichtiger Schritt, um die beste Plattform für meine Anforderungen zu finden.

- Erstellung und Konfiguration des Systems in der Yocto-Umgebung: Ich werde das Yocto-Framework verwenden, um mein Embedded Linux System zu erstellen und zu konfigurieren. Yocto bietet viele Tools und Funktionen, die mir bei der Erstellung und Konfiguration meines Systems helfen können.

- Verbesserung der Reaktionszeit und Zuverlässigkeit von Roboteranwendungen: Mein Hauptziel ist es, herauszufinden, wie die Integration von Echtzeitfunktionen und effizienten Kommunikationssystemen die Reaktionszeit und Zuverlässigkeit von Roboteranwendungen verbessern kann. Ich strebe an, die Leistung und Zuverlässigkeit meiner Roboteranwendungen zu verbessern, indem ich ihre Fähigkeit verbessere, in Echtzeit auf Ereignisse zu reagieren.

- Anbindung eines Roboters über eine VARAN-Bus Schnittstelle: Ich plane, einen Roboter in mein System zu integrieren. Ich werde eine VARAN-Bus Schnittstelle verwenden, um eine schnelle und zuverlässige Kommunikation zwischen dem Roboter und dem Steuerungssystem zu gewährleisten.

Querverweise werden in LaTeX automatisch erzeugt und verwaltet, damit sie leicht aktualisiert werden können. Hier wird zum Beispiel auf Abbildung **??** verwiesen.

Figure 1: Beispiel für die Beschriftung eines Buchrückens.

Und hier ist ein Verweis auf Tabelle **??**. Das gezeigte Tabellenformat ist nur ein Beispiel. Tabellen können individuell gestaltet werden.

Hier wird auf die Formel **??** verwiesen.

Figure 2: 2. Beispiel für die Beschriftung eines Buchrückens.

Table 1: Semesterplan der Lehrveranstaltung „Angewandte Mathematik“.

Datum	Thema	Raum
20.08.2008	Graphentheorie	HS 3.13
01.10.2008	Biomathematik	HS 1.05

Table 2: 2. Semesterplan der Lehrveranstaltung „Angewandte Mathematik“.

Datum	Thema	Raum
20.08.2008	Graphentheorie	HS 3.13
01.10.2008	Biomathematik	HS 1.05

$$x = -\frac{p}{2} \pm \sqrt{\frac{p^2}{4} - q} \tag{1}$$

$$x = -\frac{p}{2} \pm \sqrt{\frac{p^2}{4} - q} \tag{2}$$

```
1 #include <iostream>
2
3 void SayHello(void)
4 {
5     // Kommentar
6     cout << "Hello World!" << endl;
7 }
8
9 int main(int argc, char **argv)
10 {
11     SayHello();
12     return 0;
13 }
```

Code 1: 1. Beispiel

µ

Literaturverweise sollten automatisch verwaltet werden, vor allem, wenn es viele Quellenverweise gibt. Beispiele sind [**Ko05a**], [**Ko05b**], [**MiGo05**], [**TeGo14**], [**HuHa07**], [**HuZi10**], [**ZiKu07**], [**He07**], [**SIE11**], [**SIE14**], [**ISO98**], [**ATM11**], [**Hu11**], [**Po10**]. Das verwendete Zitierformat (bzw. das Format des Literaturverzeichnisses) ist entspechend der Vorgaben der

Studiengänge zu wählen. Es wird dringend empfohlen, BibTeX zu verwenden (wie in diesem Beispiel).

3 Hauptteil

4 Resultate

5 Diskussion

6 Zusammenfassung und Ausblick

List of Figures

List of Tables

List of Code

List of Abbreviations

ABC Alphabet

WWW world wide web

ROFL Rolling on floor laughing

A Anhang A

B Anhang B