FACULTY OF APPLIED SCIENCES
UNIVERSITY
OF WEST BOHEMIA

DEPARTMENT OF
COMPUTER SCIENCE
AND ENGINEERING

Computer Vision Applications in Video Recordings for Traffic Signal Detection and Classification on Czech Railways

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Podklad pro zadání DIPLOMOVÉ práce studenta

Jméno a příjmení:	**Bc. Daniel SCHNURPFEIL**
Osobní číslo:	**A22N0074P**
Adresa:	Luženická 677, Domažlice – Týnské Předměstí, 34401 Domažlice 1, Česká republika
Téma práce:	Využití metod počítačového vidění ve videozáznamech pro detekci a klasifikaci návěstidel na českých železnicích
Téma práce anglicky:	Computer Vision Applications in Video Recordings for Traffic Signal Detection and Classification on Czech Railways
Jazyk práce:	Angličtina
Vedoucí práce:	Ing. Pavel Mautner, Ph.D. Katedra informatiky a výpočetní techniky

Zásady pro vypracování:

- Seznamte se s problematikou návěstidel a návěstních znaků, zejména se zaměřením na jejich vizuální charakteristiky a odlišnosti.
- Prostudujte videa z veřejně dostupných zdrojů (např. YouTube kanál parnici.cz) obsahující železniční návěstidla.
- Navrhněte a implementujte metody pro získání snímků popřípadě sérií snímků návěstidel/návěstních znaků z dostupných videozáznamů.
- Navrhněte metody a implementujte řešení pro detekci a klasifikaci světelných návěstidel, případně návěstních znaků.
- Na dostatečně velké množině dat ověřte funkčnost implementovaných řešení.
- Zhodnoťte a popište dosažené výsledky.

Seznam doporučené literatury:

Dodá vedoucí diplomové práce.

Podpis studenta: Datum:

Podpis vedoucího práce: Datum:

Declaration

I hereby declare that this Master's Thesis is completely my own work and that I used only the cited sources, literature, and other resources. This thesis has not been used to obtain another or the same academic degree.

I acknowledge that my thesis is subject to the rights and obligations arising from Act No. 121/2000 Coll., the Copyright Act as amended, in particular the fact that the University of West Bohemia has the right to conclude a licence agreement for the use of this thesis as a school work pursuant to Section 60(1) of the Copyright Act.

V Plzni, on 28 February 2025

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Daniel Schnurpfeil

Abstract

English abstract

Abstrakt

Czech abstract

Keywords

computer vision • czech railways

Contents

Introduction

Czech Railways

todo - tady krátké intro

todo - zmínit evropský zabezpečovací systém, siemens mobility ...

2.1 Situation in Recent Years

todo - tady popsat situaci v čechách a na moravě (slezku)
todo - zmínit - Dopravní a návěstní předpis pro tratě nevybavené evropským vlakovým zabezpečovačem a že to je hlavní zaměření

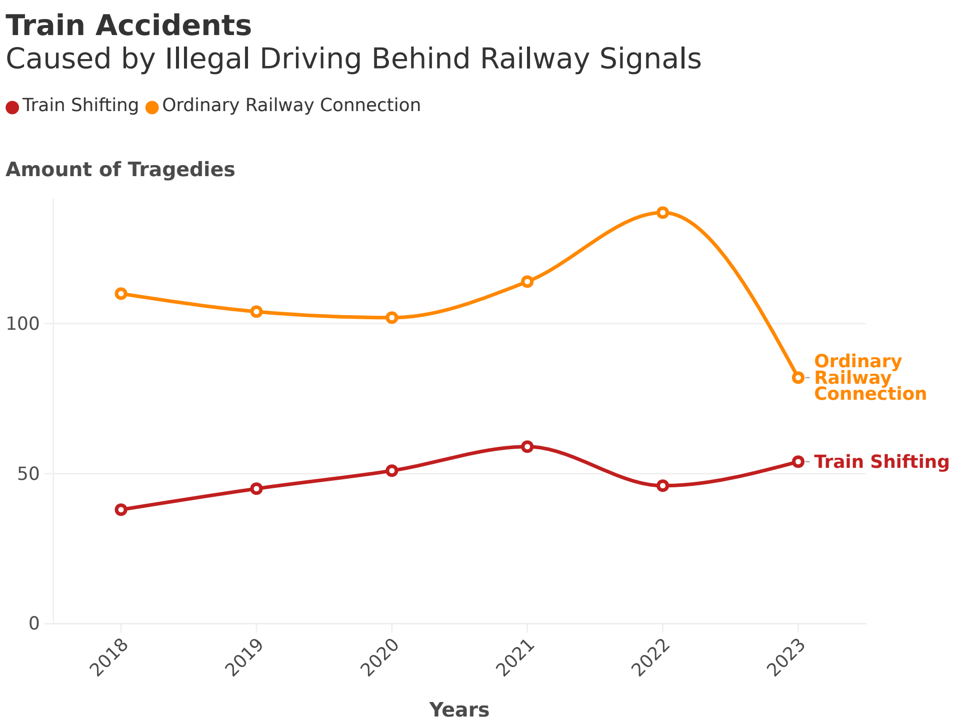

Figure 2.1: Train Accidents Caused by Illegal Driving Behind Railway Signals

2.2 Railway Signals

Railway signals represent a visual communication tool for train drivers. Their main purpose is to show important safety information for train driver. These signals contain specific combinations of lights, shapes, and colors to transmit clear instructions about speed limits, track availability, and required actions.

Light signals on Czech railways operate through a system of colored lights mounted on standardized signal posts. The most frequent signal colors are red, green, yellow, and white, with each color that carry distinct meaning. Red lights typically indicate stop request, while green lights could allow unlimited movement. The yellow light serves as a warning sign, preparing drivers for the following limitations. White lights are often in shunting[1] signals or as additional indicators.

The signals combine these colors in various patterns to communicate more complex messages. For example, two vertically positioned yellow lights (Figure 2.2) inform the driver to reduce speed and expect a stop signal ahead. The position and blinking of light(s) adds another piece of information to the basic colors.

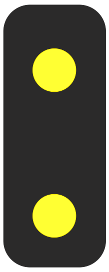

Figure 2.2: Limit 40 km/h and warning

Fixed railway signs complement the light-based system. These include physical signs and markers that display speed limits, distance warnings, and track identification. Their design emphasizes visibility in various weather conditions through reflective materials and high-contrast color schemes. Signal boards often use standardized shapes such as circles or white triangles that serve as warning signs. They are not part of the thesis.

[1]Shunting in railways is the process of moving trains, wagons within a station to assemble, disassemble, or relocate them for operational purposes.

2.2.1 Fore signal (Předvěst)

In Article 101 of the regulation, they describe fore signal in czech called ("předvěst"). This signal is dependent on main signal. Typically, this signal adds another notification for the train driver before the driver could see the main signal.

2.2.2 Single-Light Signals

In this section we will describe single-light signals and their characteristics described in the railway signaling regulation SŽ D1 Část První. It is important to mention that described signaling systems on railway tracks are not equipped with the European Train Control System.

There are several distinct single-light signals, each characterized by a specific color and blinking pattern. For example, the "Volno" signal, represented by a steady green light, allows the train to run.

On dependent signals at upstream points fore signals (předvěsti), this signal indicates there is a similar signal on the following main signal. In contrast, signals such as

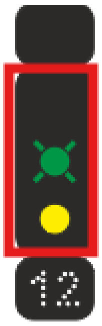

Figure 2.3: Návěst Volno (steady green light)

"Očekávejte rychlost 40 km/h" (slowly flashing yellow light) or "Očekávejte rychlost 100 km/h" (rapidly flashing green light) permit train movement while preparing the driver for a speed restriction at the subsequent signal, typically positioned at least at braking distance. These speed-related signals are from 40 km/h to 120 km/h. they are realized by patterns slow or rapid flashing and colors (yellow or green). **[Space reserved for Figure: Obrázek 103 - Návěst Očekávejte rychlost 100 km/h (rapidly flashing green light)]**

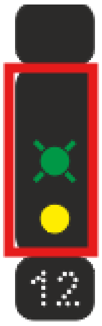

Figure 2.4: Návěst Očekávejte rychlost 40 km/h (slowly flashing yellow light)

2.2.3 Stop Signal (návěst Stůj)

todo - tady popsat, info ze zdroje - ./czech-railway-trafic-lights-detection/resources/
text_resources/Výtah světelných návěstidel červená.pdf

2.2.4 Multiple-Light Signals

todo - tady popsat, info ze zdroje - ./czech-railway-trafic-lights-detection/resources/
text_resources/Výtah světelných návěstidel ostatni.pdf

State of The Art

this is related[**Staino2022**]

Data Analysis & Methodology

4.1 Data Resources

4.2 ETL

Study of publicly available sources (e.g., YouTube channel parnici.cz) Methods for extracting individual frames and image sequences ... [**lin2015microsoft**]

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`Limitations`

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Proposed methods for identifying light signals in images

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parnici cz a strojvedouci .com

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+

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