Women in Data Science Worldwide

نحو مدن سعودية ذكية: تجاوز التحديات من أجل مستقبل مستدام

Towards Smart Saudi Cities: Overcoming Challenges for a Sustainable Future

Thursday 10 October 2024

AIADS مركز التميز البحثي في الذكاء الاصطناعي وعلم البيانات Center of Research Excellence in Artificial Intelligence and Data Science

المعلوماتية الصحية بالعربي

سبان

وزارة الاتصالات وتقنية المعلومات MINISTRY OF COMMUNICATIONS AND INFORMATION TECHNOLOGY

العطاء الرقمي Digital Attaa

صيتك

Women in Data Science Worldwide

Towards Smart Saudi Cities:

Overcoming Challenges for a Sustainable Future

Dr. Mashael Khayyat
University of Jeddah

Dr. Nadine Akkari
Jeddah International College

Dr. Sultanah Alshammari
AIADS – King Abdulaziz University

WiDS Jeddah 2024

AIADS مركز التميز البحثي في الذكاء الاصطناعي وعلم البيانات Center of Research Excellence in Artificial Intelligence and Data Science

المعلوماتية الصحية بالعربي

سبان

وزارة الاتصالات وتقنية المعلومات MINISTRY OF COMMUNICATIONS AND INFORMATION TECHNOLOGY

العطاء الرقمي Digital Attaa

صيتك

Women in Data Science Worldwide

Towards Smart Saudi Cities:
Overcoming Challenges for a Sustainable Future

Traffic Management & Road Safety: Smart Solutions
إدارة المرور والسلامة على الطرق :حلول الذكية

WiDS Jeddah 2024

Dr. Sultanah Alshammari
AIADS – King Abdulaziz University

AIADS مركز التميز البحثي في الذكاء الاصطناعي وعلم البيانات Center of Research Excellence in Artificial Intelligence and Data Science

المعلوماتية الصحية بالعربي

سيان

وزارة الاتصالات وتقنية المعلومات MINISTRY OF COMMUNICATIONS AND INFORMATION TECHNOLOGY

العطاء الرقمي Digital Attaa

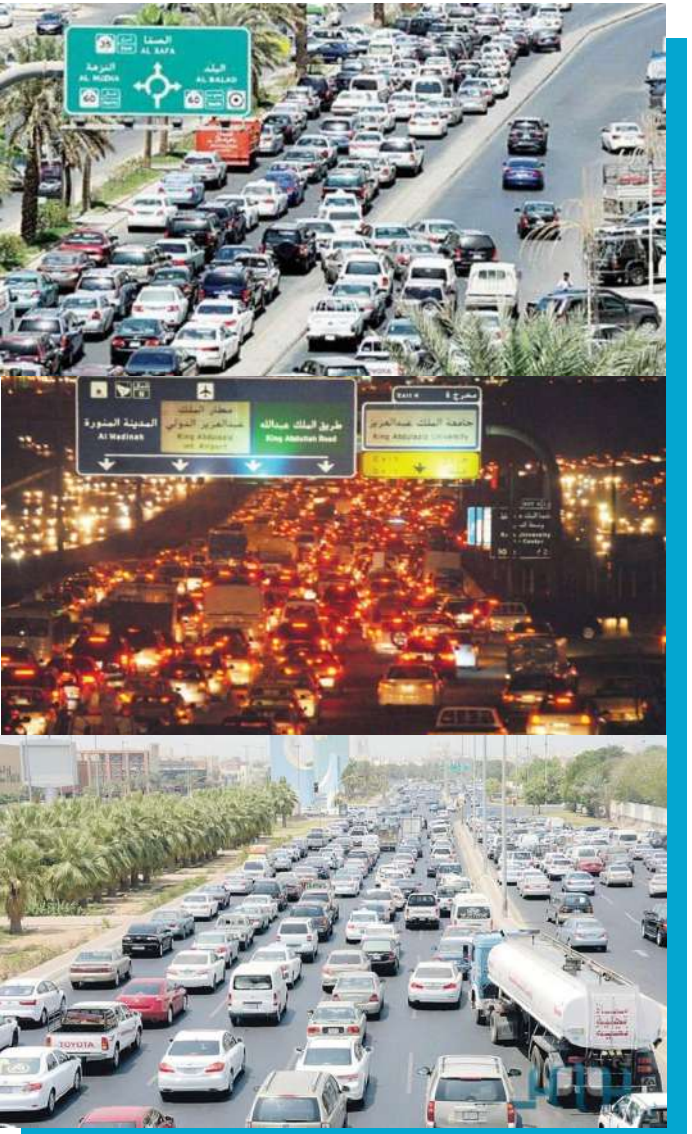
صيتك

Outline

- Introduction
- Current Traffic Management Challenges
- Key Technologies in Smart Traffic Management
- Adaptive Traffic Light Systems
- Data-Driven Road Safety Solutions
- Case Studies:
  - Adaptive Traffic Light Control System using Thermal Images
  - Classifying Nearby Cars' Behaviors Using Front Dashcam Videos

Introduction

- Traffic demand often grows over time, thus traffic congestion can occur simply because the road or intersection capacity has not been designed for the actual traffic demand, especially during peak hours.
- Traffic Congestion is a traffic phenomenon characterized by slower vehicle speeds, longer trip times, and increased queuing of vehicles.
- Road Safety is essential to prevent road users (drivers, cyclists, motorists, vehicle passengers, pedestrians) from being killed or seriously injured.
- Effective measures should be taken to ensure a safer and more sustainable traffic environment for everyone, reducing the likelihood of accidents and fostering a culture of responsible driving.



Jeddah Traffic Congestion

The yearly cost of driving in Jeddah during rush hour?

- How much time did you spend driving
- How did it affect your finances and the environment?

Travel time
(yearly)

119 h
time spent driving

40 h due to congestion

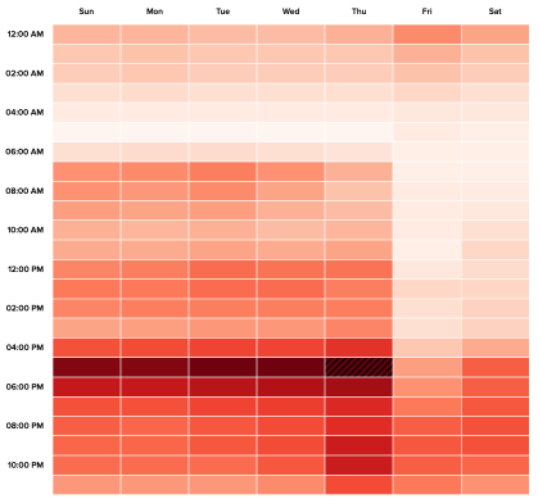
23 x Approximately **23 books**

Emissions
(yearly)

733 kg
CO_2 emitted

89 kg due to congestion

73 x **73 trees** grown over a year to absorb



Commute one-way driving drive 10 km

Thursday: 5 PM - 6 PM
Average time to drive 10 km: 18 min 30s

Current Traffic Management Challenges

- **Traffic Congestion**
  - Annual traffic growth: Jeddah: 3.5% to 4% and Riyadh 5% to 8%.
  - Limited public transport options.
  - Insufficient infrastructure:
    - Flaws in road designs and the limited capacity of highways.
    - For “micromobility” solutions like shared bikes or scooters.
  - High carbon emissions: The transport sector was responsible for 25% of the total CO_2 emissions in Saudi Arabia.

- **Road Safety**
  - Rapid urbanization and traffic growth
  - High accident rates
    - Inadequate pedestrian infrastructure
    - Cultural driving behavior: Speeding, reckless driving, disregard for traffic laws, and distracted driving)

How Can Traffic Congestion be Mitigated?

- Invest in Infrastructure:
  - Increasing the road system capacity by adding new lanes to existing roads.
  - Building new roads, highways, bridges, and tunnels.
- Invest in public transportation.
- Implement and enforce strict traffic laws and regulations.
- Improve Traffic Management and Coordination
  - One of the cornerstones in smart city design is having an integrated smart transportation solution.
  - **Intelligent Transportation Systems**, or **Smart Traffic Management Systems**, provide an organized, integrated approach to minimizing congestion and improving safety on city streets through connected technology.

How to Prevent Road Accidents?

- Infrastructure:
  - Assessing the safety of road infrastructure
  - Installing 1,300 signboards to warn drivers of dangers
  - Lighting 113 intersections with solar energy
  - Increasing the number of camera systems.
- Implement and enforce strict traffic laws and regulations.
  - Establishing automated traffic enforcement systems for serious violations on speeding (Saher System), crossing red lights, the non-use of seatbelts, and using mobile phones.
- Monitoring road user behavior to identify areas where additional reinforcement is needed.
- Spreading a culture of safe driving across the country.
- **Smart Systems** and **high-tech car safety technologies**.

Key Technologies in Smart Traffic Management

IoT & Sensors

- IoT-based systems use a network of sensors, cameras, and connected devices to monitor various aspects of traffic, allowing for real-time adjustments to improve traffic flow and safety.
- Smart traffic management systems use integrated sensors & cameras like:
  - Radiofrequency identification (RFID) tags
  - Automatic identification and data collection (AIDC) tags
  - Thermal and CCTV cameras
  - Temperature sensors
  - Air quality sensors

Connectivity

- 5G is the current state-of-the-art wireless communication technology, known for its ultra-fast data transfer speeds, low latency, and massive connectivity capacity.
- 5G enables rapid communication among traffic sensors, lights, vehicles, and central systems.
- 5G can connect millions of devices per square kilometer, making it ideal for densely populated urban environments with numerous IoT devices, vehicles, and sensors.

Predictive Analytics

- Predictive analytics uses data, statistical algorithms, and machine learning techniques to identify the probability of future outcomes based on historical information.
- AI-powered analytics can analyze data from various sources, including IoT devices, traffic cameras, and even social media posts, to predict traffic in real time.

Key Data-Driven Road Safety Solutions

Predictive Analytics for Accident Prevention

- Predictive models analyze large datasets, such as weather conditions, traffic density, and historical accident data, to forecast potential accidents or identify high-risk zones.
- Authorities can then use this information to implement preventive measures, such as adjusting speed limits, improving signage, or increasing law enforcement presence in specific areas.

Real-Time Data

- IoT-enabled traffic systems collect real-time data on traffic flow, vehicle speeds, and road conditions.
- Real-time data can be collected from cameras and sensors to detect violations like speeding, running red lights, and unsafe lane changes.

Driver Behavior Monitoring

- Companies and traffic authorities can identify risky behaviors, such as speeding or distracted driving, and take corrective actions through coaching programs or penalties.
- Driver Monitoring Systems uses sensors, such as in-car cameras, computer vision, and artificial intelligence to bring insight into the driver's state and behavior.

Traffic Flow & Traffic Lights

- Traffic lights automatically control the flow of traffic at junctions.
- Traditional traffic lights operate on fixed cycles or are manually operated
- Traffic lights at intersections work independently for each direction of traffic based on a signal phase system, controlling the flow of vehicles and pedestrians in each direction.
- The duration of each light cycle (red, yellow, green) is usually pre-programmed and may vary based on the time of day, traffic volume, and location.
- Major intersections typically have pedestrian signals, often coordinated with traffic lights.

Adaptive Traffic Lights

- Smart cities can achieve a harmonious traffic flow by utilizing real-time data for responsive traffic signal control.
- Some intersections have sensors or loops embedded in the road to detect the presence of vehicles. Data from these sensors can be used to adjust the light cycle to accommodate changes in traffic flow, ensuring smoother operation during peak and off-peak hours.
- Smart traffic light systems incorporate artificial intelligence and Machine Learning techniques to enable computer vision, optical character recognition, and reinforcement learning.
- Adaptive Traffic Lights lead to energy savings, contributing to both environmental protection and economic efficiency.
- Adaptive Traffic Lights reduce traffic congestion and enhance air quality, traffic safety, and, in turn, the quality of life in cities.

20%
Reduce travel time

40%
Less waiting time

20%
Friendly to environment

Data Sources in Adaptive Traffic Lights

Radar Sensors

- Radar sensors deliver the exact speed of traffic participants - which is crucial for calculating the estimated arrival time at the stop line.
- Sensor installation can be integrated into existing infrastructure.
- Even in adverse weather and visibility conditions, radar sensors continue to provide valuable data.

Induction Loops

- Inductive loop traffic detectors are installed on the pavement to detect vehicles passing or arriving at a certain point.
- The accuracy of the inductive loop may vary depending on the sensitivity, and frequency settings, condition of the cables in the ground, integrity of the cable joints, profile of the vehicles passing over the loops, and environmental conditions.

Cameras

- Incorporating CCTV cameras and thermal cameras into smart adaptive traffic lights offers a robust and versatile system for traffic management.
- These cameras help count the number of vehicles at intersections or along streets, aiding in adjusting the traffic light timings.

Advanced Traffic Management System in Jubail Industrial City

- Jubail Industrial City is one of the first smart and digital cities that activated and implemented the use of traffic sensors and cameras on all its streets and main roads.

- Using cameras and sensors to analyze vehicle movement data in real-time. The system has 548 cameras distributed throughout the city, monitoring roads, classifying vehicles, and adjusting traffic signals based on traffic volume.

- Traffic lights can be controlled by authorized ambulance teams from a certain distance.

AIADS
مركز التميز البحثي في
الذكاء الاصطناعي وعلم البيانات
Center of Research Excellence in
Artificial Intelligence and Data Science

AIADS
Summer Training Program

AI-based Research Track

AI-enabled traffic management systems dynamically adjust traffic flow, reducing congestion and enhancing safety.

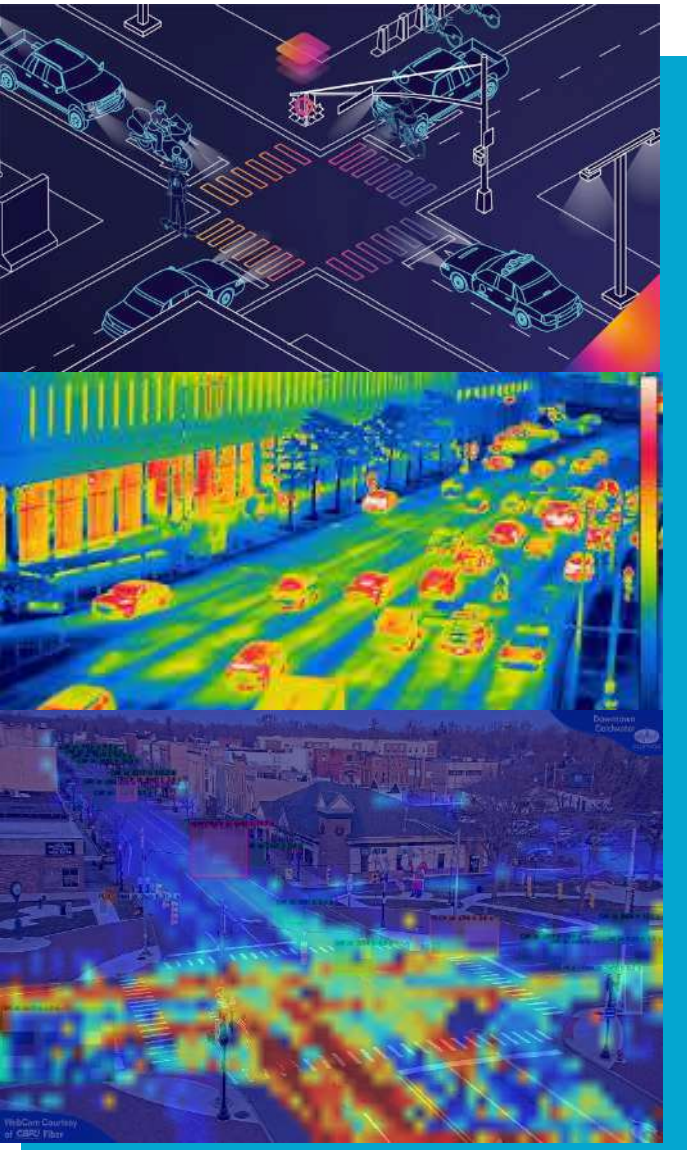
Project 1: Adaptive Traffic Light Control System using Thermal Images

This project aims to develop an adaptive traffic light system that leverages thermal camera images and deep learning techniques to analyze and optimize traffic flow in real-time

The system will dynamically adjust traffic light timings to reduce congestion and improve overall traffic efficiency.

Objective: Develop an adaptive traffic light system that uses thermal camera images and deep learning techniques to optimize traffic flow in real-time. This system aims to reduce congestion and improve traffic efficiency by dynamically adjusting traffic light timings based on current traffic conditions.

Omar Madani, Reema Al-Kuraydis, Ahmad Al-Jeedani, and Ayatun Ara
Faculty of Computing and Information Technology
King Abdulaziz University



Project 1: Adaptive Traffic Light Control System using Thermal Images

- **Dataset Generation and Pre-processing**
  - Synthetic dataset of heatmaps that simulate realistic traffic scenes with real-time weather data.
  - To enhance the generated, several adjustments were implemented:
    - Perspective Transformation
    - Image subtraction and masking
    - Synthetic Road Heat
    - Edge Detection
    - Clustering of heatmap images to highlight areas of high and low traffic congestion
- **AI Model**
  - Extreme Gradient Boosting (**XGBoost**): Powerful machine learning algorithm useful for classification and regression problems with the capability to handle non-linear relationships, which are dominant in traffic data.
- **Simulation and System Testing**
  - **Simulation of Urban Mobility** (SUMO): An open-source, simulation package designed to handle a wide range of traffic and transportation scenarios.
  - A simulation involving four intersections is developed capturing detailed variables such as the number of cars present at each traffic light and the specific time of day and week.

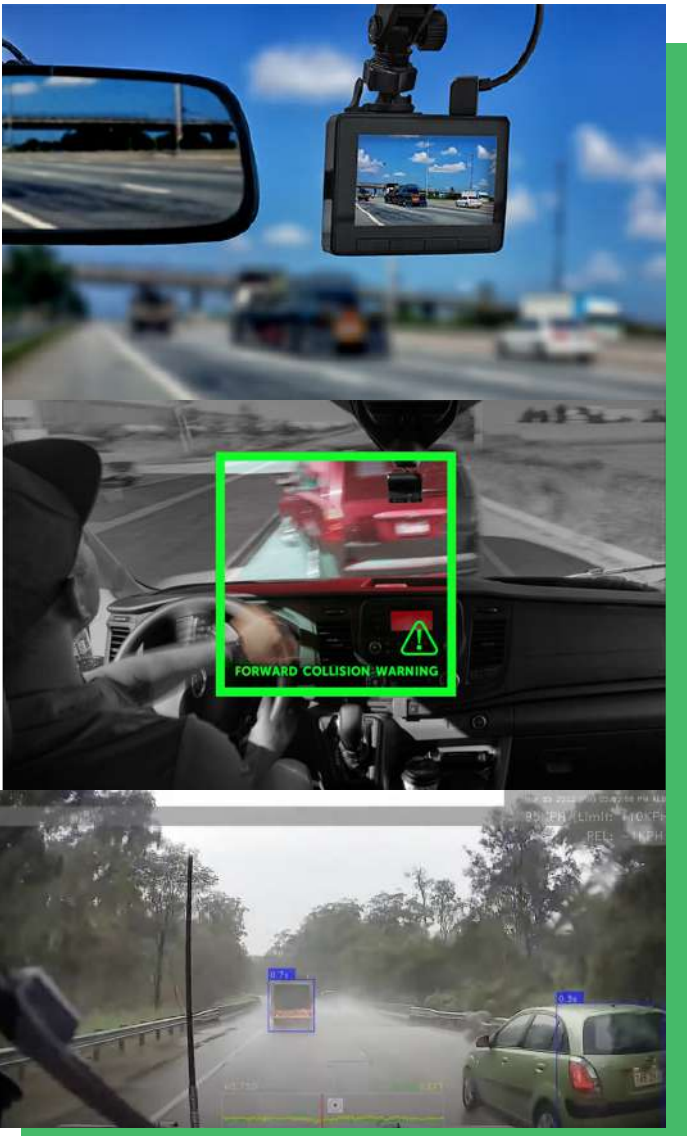
Project 2: Classifying Nearby Cars' Behaviors Using Front Dashcam Videos

This project aims to develop a system to predict potential accidents by analyzing the behavior of nearby cars using dashcam footage.

By applying deep learning techniques, the system will identify dangerous driving behaviors and provide early warnings to prevent accidents.

Objective: Develop an AI model to predict potential accidents by analyzing the behavior of nearby cars using dashcam footage. By applying deep learning techniques, the proposed system will identify dangerous driving behaviors and provide early warnings, thus preventing accidents and enhancing road safety.

Ammar Bin Madi, Raghad Alharbi, Samaher Alotabibi, Ammar Alrefai, and Ahmed Saleh
Faculty of Computing and Information Technology
King Abdulaziz University



Project 2: Classifying Nearby Cars' Behaviors Using Front Dashcam Videos

- **Dataset & Car's Behaviors**
  - Total Number of Videos: 3,375 of approximately 33 hours
  - Based on the categorized data, our objective is to develop a model that classifies the behavior of nearby cars into one of the three categories:
    - Lane Changing
    - Driving Against Traffic
    - Sudden Braking
- **AI Model**
  - **3DCNN**: A neural network designed to handle spatial and temporal aspects of video data through 3D convolutional filters.
  - **Optical Flow**: A technique to estimate motion between frames in a video, providing flow vectors that indicate the direction and speed of moving objects.
  - **Long Short-Term Memory (LSTM):** Models long-term dependencies across sequences, enhancing understanding of temporal dynamics over time.

3DCNN		3DCNN + LSTM
83.00%	Model Accuracy	84.72%

References

- Traffic Statistics Source (2024), URL: https://www.tomtom.com/
- Traffic Statistics Source (2024), URL: https://www.kapsarc.org/research/publications/saudi-arabia-net-zero-ghg-emissions-by-2060-transformation-of-the-transport-sector/
- What is a Smart Traffic Management System? Jari Haiston , March 11, 2024. https://www.symmetryelectronics.com/blog/what-is-a-smart-traffic-management-system/
- Aljoufie M. The Impact Assessment of Increasing Population Density on Jeddah Road Transportation Using Spatial-Temporal Analysis. Sustainability. 2021; 13(3):1455. https://doi.org/10.3390/su13031455
- Aljoufie M, Tiwari A. Modeling Road Safety in Car-Dependent Cities: Case of Jeddah City, Saudi Arabia. Sustainability. 2021; 13(4):1816. https://doi.org/10.3390/su13041816
- WHO, Reducing Road Crash Deaths in the Kingdom of Saudi Arabia (2023). URL: https://www.who.int/news/item/20-06-2023-reducing-road-crash-deaths-in-the-kingdom-of-saudi-arabia

Women in Data Science Worldwide

Thank You!

Dr. Sultanah Alshammari
AIADS – King Abdulaziz University
sshammari@kau.edu.sa

نحو مدن سعودية ذكية:
تجاوز التحديات من أجل مستقبل مستدام

Towards Smart Saudi Cities: Overcoming Challenges for a Sustainable Future

AIADS مركز التميز البحثي في الذكاء الاصطناعي وعلم البيانات Center of Research Excellence in Artificial Intelligence and Data Science