Intelligent parking based on monitoring analysis(2023)

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***Abstract*—In today's world of dynamically developing cities and an ever-increasing number of motor vehicles, parking management has become a key challenge. In response to this need, the "Intelligent Multi-Story Parking Based on Video Analysis" project introduces an innovative approach to solving problems related to limited parking space. In this article, we present the concept of this advanced parking system that uses video analysis from cameras to effectively manage available parking spaces on multiple levels.**

Keywords— Parking share, IoT system, Automated parking, Image processing, Website application

I. INTRODUCTION

Over 766,683 people live in Krakow , and in the Krakow's agglomeration there are over 1.5 million people, and there are 0.68 cars for every resident of Krakow. This gives 525,000 registered cars. Taking into account the entire agglomeration, where this ratio is higher on its outskirts, it can be assumed that 700,000 cars need parking in the city, as over 200,000 additional cars enter the city every day(https://www.krakow.pl/aktualnosci/216234,26,komunikat, do_krakowa_wjezdza_dziennie_cwierc_miliona_samochodow .html).

The trend is rather upwards, so every year there will be a need for more and more parking spaces. In response to this problem, the idea of building relatively cheap and common intelligent multi-storey parking lots was created.

Smart parking systems are implemented worldwide, mainly in Europe, United States and Japan. Implementation of smart parking systems has many advantages for municipality, parking owners and drivers. Drivers can easily find vacant parking lots and avoid driving to fully occupied parkings, this also minimizes the air pollution which will definitely help in Krakow's conditions.

Smart parking systems usually are divided into several categories: parking guidance and information system (PGIS), transit based information system, smart payment system, E-parking and automated parking. Each system has its advantages and disadvantages. This paper deals with parking guidance and information system sub-component, named parking lot occupancy detection. Critical point in smart parking operation is parking lot occupancy detection. There are many technologies available for this, which are mainly divided into two categories: intrusive (inductive loops, piezoelectric cables, active infrared sensors, etc.) and nonintrusive (passive infrared sensors, ultrasonic, video image processing, etc.).

II. BACKGROUND STUDY

A. Image

An image is defined as a two-dimensional function,F(x,y), where x and y are spatial coordinates, and the amplitude of F at any pair of coordinates (x,y) is called the intensity of that image at that point. When x,y, and amplitude values of F are finite, we call it a digital image.
In other words, an image can be defined by a two-dimensional array specifically arranged in rows and columns.
Digital Image is composed of a finite number of elements, each of which elements have a particular value at a particular location. These elements are referred to as picture elements, image elements, and pixels. A Pixel is most widely used to denote the elements of a Digital Image.

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$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & f(0,2) & \dots & f(0,N-1) \\ f(1,0) & f(1,1) & f(1,2) & \dots & f(1,N-1) \\ \vdots & \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & f(M-1,2) & \dots & f(M-1,N-1) \end{bmatrix}$$

B. Image processing

Image processing is the process of transforming an image into a digital form and performing certain operations to get some useful information from it. The image processing system usually treats all images as 2D signals when applying certain predetermined signal processing methods.

There are five main types of image processing:

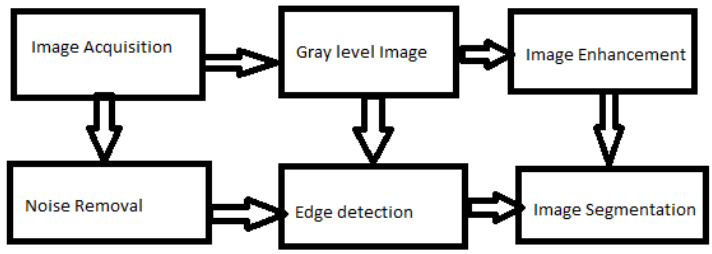
- Visualization - Find objects that are not visible in the image
- Recognition - Distinguish or detect objects in the image
- Sharpening and restoration - Create an enhanced image from the original image
- Pattern recognition - Measure the various patterns around the objects in the image
- Retrieval - Browse and search images from a large database of digital images that are similar to the original image

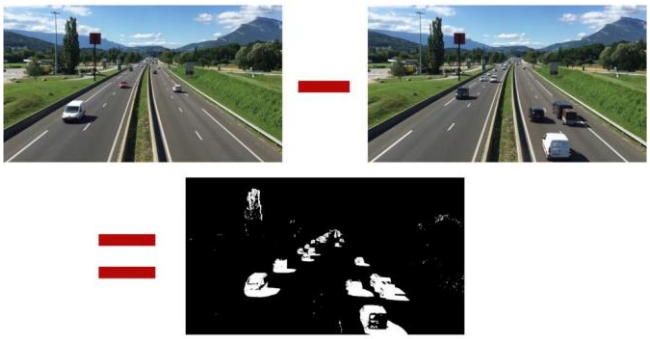
Especially pattern recognition will be used in particular in this project to recognize license plates or detect objects appearing in the camera view. Camera image management and processing will be handled by a specially designed algorithm written in Python. It will do this with the help of two specialized libraries: OpenCV and TensorFlow.

OpenCV is a huge open-source library for computer vision, machine learning, and image processing. OpenCV supports a wide variety of programming languages like Python, C++, Java, etc. It can process images and videos to identify objects, faces, or even the handwriting of a human. When it is integrated with various libraries, such as NumPy which is a highly optimized library for numerical operations, then the number of weapons increases in your Arsenal i.e. whatever operations one can do in NumPy can be combined with OpenCV. The OpenCV library, like any other library of its kind, uses fundamental steps to process an image:

- Image Acquisition
- Image Enhancement
- Image Restoration
- Color Image processing
- Wavelets and Multiresolution Processing
- Compression
- Morphological Processing
- Segmentation
- Representation and Description
- Recognition

TensorFlow is an open-source software library. TensorFlow was originally developed by researchers and engineers working on the Google Brain Team within Google's Machine Intelligence research organization for the purposes of conducting machine learning and deep neural networks research, but the system is general enough to be applicable in a wide variety of other domains as well! Let us first try to understand what the word TensorFlow actually mean! TensorFlow is basically a software library for numerical computation using data flow graphs where:





C. Importance of the problem

Smart multi-storey car parks are now not only a convenient solution, but also a necessity in cities with high population density and limited space.

Saving Space: Multi-level parking lots allow for efficient use of limited urban space by allowing parking on several levels. This allows many more vehicles to be accommodated in the same area, which is extremely important in congested urban areas.

Reducing Air Pollution: Smart parking allows drivers to find a parking space quickly and efficiently, reducing the time spent searching for parking. This results in lower fuel consumption and fewer harmful substances emitted into the atmosphere, contributing to improved air quality in the city.

Improved Traffic: Less time spent looking for parking also means less traffic congestion. Drivers don't wander around looking for a parking space, which helps to make traffic flow smoother while reducing the number of road accidents.

Improving Urban Mobility: Smart parking lots enable integration with public transport systems, enabling easier transfers between cars and other modes of transport. This helps to promote more sustainable and ecological methods of moving around the city.

Space Utilization Optimization: Smart parking systems collect data on the use of parking spaces, which allows for optimization of urban space planning. This data is valuable to city planners and city planners, helping to plan better and more effective urban solutions.

As a result, the development of intelligent multi-level car parks not only improves the quality of life of residents, but also contributes to the sustainable development of cities, increasing their attractiveness as places to live, work and spend free time. As the urban population and the number of vehicles increase, it is necessary to continue the development of these intelligent parking systems to effectively manage traffic and space in the cities of the future.

III. PROBLEM FORMULATION

A. Research platform design:

The project requires the design and production of a model of a multi-level parking lot, equipped with parking spaces, traffic zones and entrances and exits. It is also worth considering expanding the model with future improvements, such as microphones or seismic sensors that will improve the operation of the system by providing more data that can be processed and processed.

B. Monitoring system:

The resulting model should be equipped with cameras in the transition zone where vehicles will enter and leave the parking lot, in the traffic zone to monitor their driving, and in parking zones to control the parking lot occupancy and identify vehicles and assign them to occupied parking spaces.

C. Algorithms:

The algorithms used in the project should recognize vehicles based on their license plates, parking spaces and traffic zones. Identify occupied places and send information to the database. And also direct traffic if necessary.

D. Data storage:

Data collected in the hardware layer should be processed and sent to an external server for storage and statistics.

E. Data management:

The implementation of the project requires that it be managed by a single-board computer and a microcontroller that directly controls electronic devices included in the model, such as servomechanisms, sound sensors, lighting, and other sensors included in the project.

IV. SOLVING PROBLEMS

A. Research platform design:

A model of a multi-story parking lot will be designed inside Fusion 360, then in the production process it will be manufactured using 3D printing technology, elements such as parking spaces, traffic zones and the necessary electronic components will be added.

B. Monitoring system:

This problem will be solved by installing several cameras coupled to a single-board computer so that the entire image precisely overlaps.

C. Algorithms:

The main challenge will be to implement appropriate algorithms in the field of image processing, in order to improve this operation I will use the existing libraries mentioned earlier in this article. A key aspect will be the use of neural networks to make the algorithms as effective as possible.

D. Data storage:

In order to implement this requirement, it will be necessary to rent an external server storing data and create a website running on it. I will use Amazon for this purpose.

E. Data management:

To manage the project I will use a single-board computer from the Raspberry Pi family and a microcontroller from the STM32 family to control electronic devices

V. TIMELINE

Estimated project implementation time is 9-10 weeks. The first milestone will be considered completed when the vehicle identification and storage system is completed and tested, and

the second one when the entire project works properly. The first one should be completed 4 weeks after starting work.

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