Research Article

Tourist Attractions Visitor Density Monitoring Platform

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ABSTRACT

Tourism is one of the sectors that have been hit hard during the current Covid-19 pandemic. However, in 2021 the tourism sector is slowly rising marked by the number of tourist attractions that are starting to open to the public with the implementation of strict health protocols. However, in practice there are still many cases of violations of health protocols in various tourist attractions, ranging from the un-disciplined use of masks, not keeping a distance (social distancing), and the absence of setting the ideal number of visitors during a pandemic like the current one. Managers of tourist attractions tend to ignore restrictions on the number of visitors due to the absence of an management system to run. There needs to be an application that can inform the condition of visitors to tourist attractions in real-time so that people have self-awareness of their personal health so that people can make early plans before traveling. In good governance, this application contributes to controlling the risk of Covid-19 transmission originating from crowded centers (tourist spots). The government can easily monitor the distribution of tourist visitor density in the area so that it can then be used as a basis for carrying out policies and handling in the field.

This study proposes the development of an application platform (software and hardware) monitoring the density of visitors to tourist attractions using the concept of object detection based on image processing and deep learning. The integration of hardware with web-based software will provide information on the density of visitors to tourist attractions that are easily accessible to the public so that they are expected to contribute to the handling of the current Covid-19 pandemic.

Keywords: tourist, pandemic, deep learning, yolo, covid.

Introduction

According Mckinsey, year 2021 will be a transition year. Holiday travel will increase again, where this pattern has already occurred

in China. It was mentioned that in the third quarter of 2020, business had started to return to normal based on the pattern of economic growth. Domestic travel is predicted to surge,

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but international travel will still be under pressure due to travel restrictions related to the pandemic and health and safety concerns (mckinsey.com, 2021). During the COVID-19 crisis, one area that has seen growth is digitalization (mckinsey.com, 2021). Digital applications are needed by the community to meet needs ranging from online food delivery services, online shopping, to remote work through video conferencing applications.

The Covid-19 pandemic has caused various economic sectors in Indonesia to experience a downturn. One of the sectors most affected is tourism. The PSBB (Large-Scale Social Restrictions) policy in the past seemed to put pressure on it. The level of tourist arrivals has decreased drastically, thus stopping the local economy. However, in 2021, various countries are promoting vaccination programs for their citizens with great hopes that in 2021 the world's conditions will recover. In Indonesia, the tourism sector looks to be starting to rise, marked by the number of tourist attractions that will begin to reopen in 2021 while still implementing disciplined health protocols.

However, in practice there are still many cases of violations of health protocols in various tourist attractions, ranging from the undisciplined use of masks, not keeping a distance (social distancing), and the absence of setting the ideal number of visitors during a pandemic like the current one. Managers of tourist attractions tend to ignore restrictions on the number of visitors due to the absence of an easy management system to run.

For this reason, it is necessary to have a platform that can inform the condition of visitors to tourist attractions at that time (real-time) to the public so that people have self-awareness of their personal health. With the existence of a special platform, people can make advance plans before traveling. In good governance, this platform contributes to controlling the risk of Covid-19 transmission originating from crowded centers (tourist spots). The government can easily monitor the distribution of tourist visitor density in the area so that it can then be used as the basis for carrying out policies or handling in the field.

The development of this platform has been through scientific studies sourced from literature studies collected from various international journals. The platform developed will implement image processing and machine learning technologies that are currently widely used to solve various solutions in society. This platform relies on hardware capabilities to calculate the number of tourist visitors in real-time. Several studies in the detection of human objects (human tracking) have been carried out, such as in Chenshu Wu's research which designed and implemented an integrated framework to detect moving and immobile people simultaneously with COTS WiFi devices (Booranawong et al., 2018). Pritam Paral uses a template matching algorithm for sight-sensing-based human tracking with robots moving in a coexistent human and robot environment (Will et al., 2019). Huquan Li uses Through-wall imaging radar (TWIR) technology for human target tracking (Wu et al., 2015). Christoph Will uses a millimeter-wave radar in the 24-GHz ISM band for the detection, tracking, and classification of human targets (Li et al., 2019). Apidet Booranawong developed a deviceless human detection and tracking system using the received signal strength indicator (RSSI) for the indoor environment (Lin and Huang, 2011).

The whole research above uses complex tools or concepts applied in the field. Then there are some studies that are easier to apply in the field with less hardware requirements and can give good results. Some of the following studies use image processing technology such as in Emrah Benli's study which uses an Omni-Directional thermal camera to track human activities (Nguyen et al., 2019). Young-Gun Lee proposes a more robust (robust) approach to tracking using multiple cameras by using online learning in an unsupervised manner (Shin et al., 2018). Daw-Tung Lin created a framework for tracking systems using collaborative multiple-cameras on overlapping and nonoverlapping fields of view (FOVs) (Benli et al., 2019). Zhiyong Yu introduced the Co-Tracking system which is used for tracking special objects using collaborative sensing between the camera and mobile phones (Li et al., 2020).

This study will use the same concept as the studies above, namely using a camera with image processing technology by implementing a deep learning algorithm that is known to be reliable for object detection applications. Several studies have used deep learning for object detection as in research

Dong Kyun Shin uses incremental active semi-supervised learning combined with batch-based active learning and bin-based semi-supervised learning for streaming object detectors in crowded environments (Zhu et al., 2020). Meimei Gong proposed a real-time motion detection and recognition system for human movement using Deep Learning and Multi-Scale feature fusion on video (Gong and Shu, 2020). Guofa Li proposes a deep learning approach for object detection on the road called ASPP-CenterNet (Paral et al., 2019). Haidi Zhu proposed a framework to solve noise problems in moving object detection using Deep Convolution Neural Networks (Xu et al., 2020)

The entire research above uses deep learning and can provide accurate results. This study proposes the use of deep learning for object detection using a deep learning model that is ready to be used without a training model process, namely the YOLO deep learning model. The Yolo model was chosen because of its ease of implementation and high accuracy. Several studies have used the YOLO model for object detection as in Wei Fang's study which used Tinier-YOLO for real-time object detection (Fang et al., 2020). Duy Thanh Nguyen created a high-performance hardware-efficient streaming architecture for real-time object detection using the YOLO model on an FPGA. Qiwei Xu uses the YOLO model for object detection on the road in driving scenarios (Lee et al., 2018).

However, the output of the above studies is only a standalone object detection application that has not been integrated with other applications. The novelty of this research lies in the integration of a hardware system developed for the detection of tourist site visitors (deep learning based) with a web-based information system that displays real-time information on the condition of tourist attractions. The input data presented in a web-based information system does not have human intervention in it,

everything runs automatically where the hardware will always send the latest information regarding the density conditions of tourist attractions to the main database via the Internet network. The process of exchanging information can occur in real-time so that people can benefit greatly from the availability of this platform.

Methodology

The research procedure begins with the preparation stage, the system design stage, the implementation stage, and the system test stage. Each stage is described in the following sub-chapters.

Preparation Stage

In the preparation stage, literature studies were carried out on several international journals using the IEEE Explorer and Sciencedirect platforms. This study was conducted to obtain a research position that will be developed among existing research (state of the art). This stage will determine the quality of the research to be developed and its contribution to science. From the results of this literature study, articles related to the research to be developed were obtained. Some of the keywords used in the Pustaka study are people counting, people image recognition, crowd counting, object detection, object tracking, object detection deep learning, YOLO object tracking, and YOLO object detection.

Design Stage

After the preparation stage is done, the next process is the design stage. The design of the system is carried out by considering the results of the literature study, which is related to the methods used for human object detection to be used and the determination of the novelty of the system to be produced. The detection method used in the development of this tourist visitor density monitoring platform is image processing using deep learning. The image processing method was chosen because it is practical, low cost, and easy to implement in the field. From the results of research that has been done, the object detection method using image processing provides accurate results.

Several object detection studies using image processing have been carried out using several image processing methods such as edge detection, but the resulting performance is not optimal. This research will use Deep Learning method which is implemented in image processing. Deep Learning is the development of a Neural Network which is currently proven to be reliable and widely used to solve various cases in machine learning.

Determining the novelty of the system is also discussed at this stage. From the results of the literature study, this research will complement existing research with software development. The results of image processing are integrated with the main application for monitoring the density of visitors to web-based tourist attractions. The results of hardware image processing are sent to the main server in real-time, so that the output of this system can be directly monitored on the provided web-based application.

The design stage is followed by software and hardware design. The system architecture developed is described in Figure 1 which consists of four layers, namely the hardware layer, communication layer, cloud layer, and application layer. The hardware layer has an important role in the development of the platform because at this layer lies the object detection application. Layer communication bridges the data transfer process from hardware to layer cloud. The communication layer uses the HTTP protocol which is a popular protocol used in modern web-based applications. The cloud layer or server functions to accommodate data sent by hardware to the database and serves to provide web services for the platform that is built. At this layer it is planned to use the Ubuntu Server 20.04 LTS operating system and MySQL database. The application layer functions as an information display and user interface. At this layer, the application is planned to be built using the PHP Framework Codeigniter and JQuery Framework.

Figure 1. System Architecture

Implementation Stage

At this stage it is divided into hardware implementation and software implementation. The hardware used in this research consists of a high-resolution web camera and a Mini Personal Computer (MiniPC) which is compatible

with deep learning processing. Hardware is placed in strategic positions at the entrance and exit of tourist attractions to detect visitors entering and leaving tourist attractions. The hardware configuration is depicted in Figure 2 as follows.

Figure 2. Hardware Configuration

The webcam used has a resolution of 1080p which is connected via a mini PC USB port. Mini PC here plays a role in processing visitor detection using image processing and deep learning. The results of the processing are then sent by the mini PC to the database server using the Internet network using REST API access. The data sent by the Mini PC is then stored in the main database and displayed to the user via the web interface.

Implementation

Software implementation is divided into two parts, namely software implementation on the hardware side and software implementation on the server side. Software on the hardware side is a visitor detection program built

using image processing and machine learning. The programming language used is Python using the machine vision library OpenCV and the YOLO deep learning model.

On the server side, a web monitoring platform is built using the PHP programming language and MySQL database. The server side program is divided into two parts, namely the web frontend program and the backend program. The backend program is used to manage monitoring applications by the main administrator. On the backend side, a web service (REST API) is also made to bridge communication between the server and machine vision hardware in the field.

Figure 3. Testing the YOLO Algorithm

Figure 4. Testing the YOLO Algorithm

Figure 5 shows the main Dashboard page of the application which displays a map of the distribution of the area and the daily accumulated number of Covid-19 cases.

Figure 5. Dashboard Page

System Delay Analysis

Table 1. Delay time

No	Time	Delay (second)
1	01-10-2021 09:00:00	1.15
2	01-10-2021 09:15:00	1.15
3	01-10-2021 09:30:00	1.13
4	01-10-2021 09:45:00	1.15
5	01-10-2021 10:00:00	0.80
6	01-10-2021 10:15:00	1.13
7	01-10-2021 10:30:00	1.14
8	01-10-2021 10:45:00	1.15
9	01-10-2021 11:00:00	0.87
10	01-10-2021 11:15:00	1.15
11	01-10-2021 11:30:00	1.15
12	01-10-2021 11:45:00	1.14
13	01-10-2021 12:00:00	0.84

The average system delay time is 1.07 seconds.

Conclusions

This study succeeded in building a web-based tourist visitor density monitoring system with a deep learning algorithm. The application is built using the yolo deep learning model. The average speed of the system response is 1.7 seconds. With these results this application can be implemented in tourist places that have a fairly high trend of visits. The development of this research is expected to be equipped with a more integrated system.

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