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A Search Model Using Time Interval Variation to Identify Face Recognition Results

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Abstract

Various types of attendance management systems are being introduced in a remote working environment and research on using face recognition is in progress. To ensure accurate worker's attendance, a face recognition-based attendance management system must analyze every frame of video, but face recognition is a heavy task, the number of the task should be minimized without affecting accuracy. In this paper, we proposed a search model using time interval variation to minimize the number of face recognition task of recorded videos for attendance management system. The proposed model performs face recognition by changing the interval of the frame identification time when there is no change in the attendance status for a certain period. When a change in the face recognition status occurs, it moves in the reverse direction and performs frame checks to more accurate attendance time checking. The implementation of proposed model performed at least 4.5 times faster than all frame identification and showed at least 97% accuracy.

Keywords: *Attendance Management System, Telecommuting, Face Recognition, Frame Identification*

1. Introduction

The attendance management system is a system that measures work performance by checking the attendance status of workers. In general, workers directly record their working status in the attendance management system. The method has the advantage of being simple but there are problems such as inaccuracy and forgery of records [1]. To solve the problems, attendance management systems using various technologies such as magnetic card, biometric identification, RFID, NFC, Bluetooth, Beacon, and GPS are being researched and used. Attendance management systems using face recognition is also being widely studied. During the COVID-19 pandemic, untact working such as telecommuting and video conferencing has become commonplace, especially in the IT industry [2]. Therefore, it is necessary to build the attendance management system to such the situation. The attendance management system using face recognition can be used on PCs, so it can be used appropriately in a place other than a designated workspace, such as home. The face recognition-based attendance management system can collect time and attendance information using real-time or recorded video of workers. To ensure accurate worker's attendance of recorded video analysis, a face

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recognition-based attendance management system must analyze every frame of the video, but face recognition is a heavy task, the number of the task should be minimized without affecting accuracy. The longer time interval for face recognition makes the lower accuracy, and the shorter the time interval needs the more time is required for analysis, so a balance should be found. In general, the time interval between changes in the attendance status may be long. Therefore, when the attendance status continues for a certain period, it may be appropriate to perform face recognition for frames at bigger time intervals instead of face recognition for all frames. In this paper, we propose a search model that performs rapid analysis by changing the time interval between frames to be identified according to the attendance status when analyzing recorded videos in a face recognition-based attendance management system. The proposed model changes frame identifying interval variably when working for a certain period based on the determined minimum working time. If the attendance status changes when moving with the changed interval, to check the status changing point of time by performing frame identification after backward moving.

The rest of this paper organized as follows. In Section 2, we review the backgrounds of our work, the proposed search model is shown in Section 3. An Implementation and discussion about the model are shown in Section 4. Section 5 concludes the paper.

2. Backgrounds

2.1 Attendance Management System

The attendance management system is a system that measures work performance by checking the attendance status of workers [1]. In the past, an attendance management system validates the working time of workers but, recently it has evolved to check working status in addition to working time. The attendance management system that checks working time which is recorded by workers directly. This type of system used various identification equipment owned by workers, such as magnetic cards and IC cards. Recently, research of attendance management system using RFID or NFC is being studied [3][4]. Besides, studies on attendance management systems using biometric information such as fingerprint and iris recognition is being researched [5]. This type of system has the advantage of being easier to check the attendance status and identify many workers compared to the existing method, but it may be difficult to apply to telecommuting because it requires additional devices for attendance management. In addition, there are restrictions on checking the working status.

With the improvement of face recognition technology, various researches on attendance management systems using face recognition is progressed [6][7][8]. The face recognition-based attendance management system analyzes real-time or recorded videos to check working time and can provide working status information using face tracking. The face recognition-based attendance management system has the advantage that it can be applied to PC or smart device, so it is easy to use to telecommuting. In general, the face recognition-based attendance management system recognizes a worker's face at a specified time interval and determines the attendance status by identifying of the recognition result. Some error may occur due to the occurrence of a poor recognition status depending on specific movements such as the direction of the face, the worker's posture. Therefore, even if a face is not recognized for a determined period, it should be recognized as the current attendance status to measure attendance accurately.

2.2 Face Recognition Tools

Face recognition has been one of the representative fields of image processing since the past, and various researches are being conducted along with biometric authentication such as iris, vein, fingerprint, and voice. In particular, face recognition technology based on deep learning is emerging, and various tools for face recognition are provided as OpenAPI [9][10][11]. The face recognition procedure can be composed of the procedures of Face Detection, Data Collections, Face Preprocessing and Alignment, and Face Recognition [5]. Various tools are provided to perform each step or the entire step. OpenCV is an open library related to computer vision and is widely used for image processing for face extraction [12]. Dlib is a C++ based library with built-in machine learning algorithms and tools, and it can be applied to face detection, face alignment, and face recognition [13]. TensorFlow is an open source platform that uses machine learning [14]. TensorFlow is used in numerous machine learning projects in the real world and is being used in various fields based on the research results. Keras is a deep learning framework for python used to create deep learning models [15]. Keras performs deep learning tasks using TensorFlow, Theano, or CNTK as a backend. OpenAPI-based face recognition system analyzes and extracts face recognition images using OpenCV or Dlib, constructs deep learning model using Keras for face recognition, and TensorFlow performs deep learning with Keras model to recognize faces results can be generated.

3. Proposed Model

3.1 Structure of Search Model

Figure 1 shows the structure of the proposed model. The video file analyzer analyzes a recorded attendance video and checks information such as play time, total frame and fps of the video. The checked information is sent to the face checker and used to move and check the frame of the video. The face checker performs face recognition on the frame after moving to the target frame located at the current time interval. Face Checker can be implemented with OpenAPI libraries. The worker’s face to be checked in the face checker has been learned as images of the worker, and the face is recognized in the frame based on the learned information. The face checker sends the result of face recognition to the attendance analyzer. The attendance analyzer analyzes the recognition data to determine the absence of the target worker's face information and the working status and creates attendance data. The attendance data can be classified into working, non-working, and absent. If other worker's face is identified, it is classified as absent. The working time manager evaluates the status of attendance and calculates total working and non-working time.

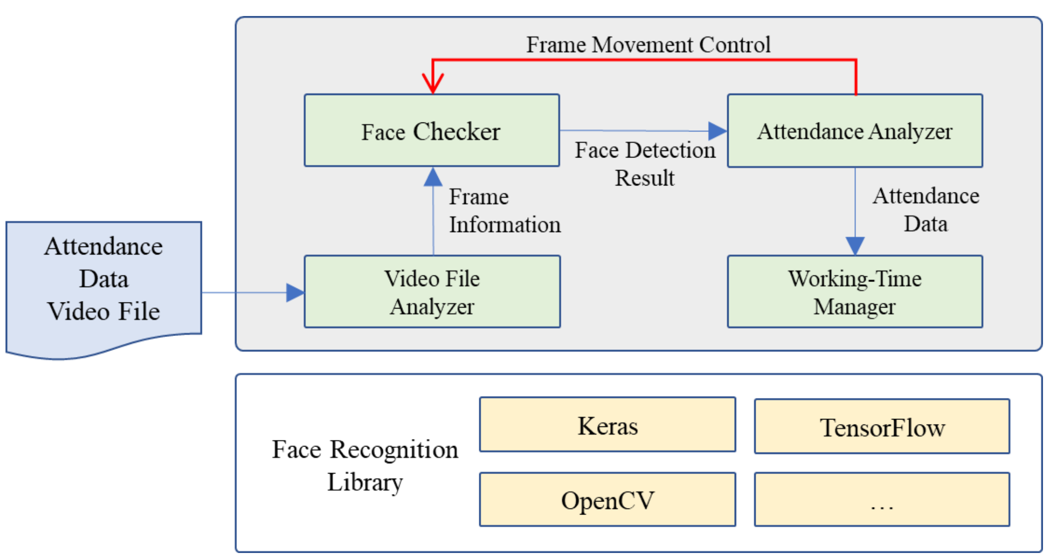


Figure 1. The structure of the proposed model

The attendance analyzer checks continuously whether the attendance data are continued in the same status. If the status of attendance data does not change for a defined time interval, the time interval is increased. The basic time interval can be specified as one second, and the increased time interval can be specified within the minimum working time that can be recognized as attendance. For example, if the minimum working time is designated as 30 seconds, even if a change in working status occurs within that time, the attendance status is evaluated to same status. Because face recognition results may appear inaccurate depending on the posture of the worker, so this is to compensate for the situation. Figure 2 shows the movement status according to the time interval change.

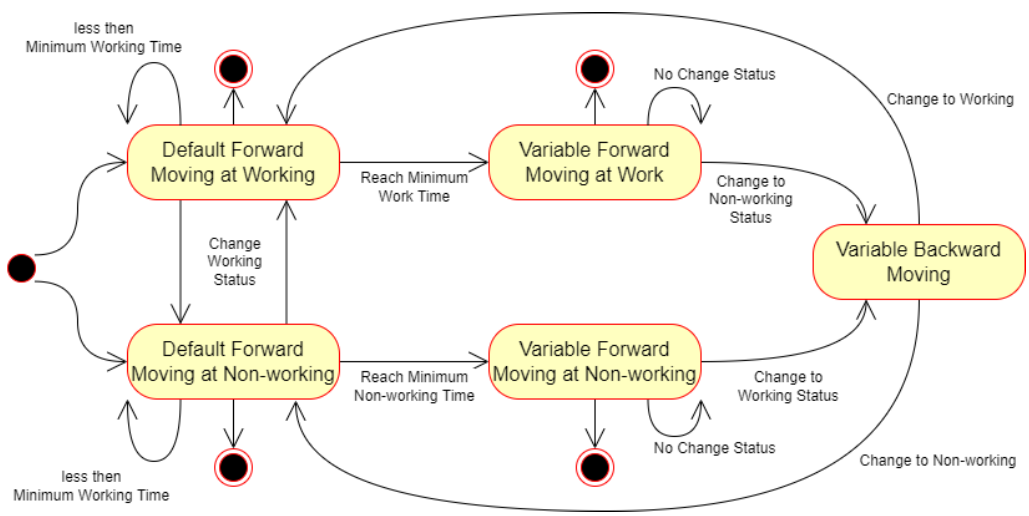


Figure 2. Movement state diagram

In the initial state, it moves to the position of the analysis target frame with the minimum time interval. If the movement of the minimum time interval continues until the minimum working time, the time interval can be increased to perform face recognition on the frame at the new time interval position. Face recognition for frames included in the increased time interval is skipped, so the number of face recognition tasks can be reduced. If the working status changes to another when applying the increased time interval, move backward to check the position of the frame which status has changed. Without applying backward moving, differences by an increased time interval may occur whenever there is a change in working status. The face recognition of the target frame is performed at basic time intervals after backward moving.

3.2 Movement Control with Time Interval

Figure 3 shows the flow chart of the operation of the attendance analyzer to implement the state of Figure 2. First, the worker is identified by analyzing the recognition result calculated by the face checker. When a worker is identified, it is checked whether the worker is a target worker, and check whether the current working status is the same as before. If the current working status is different from the previous one when the increased time interval is applied, the reverse movement is set to find the status change frame. When the working status is the same, it is checked whether the minimum working time have been met, and the increased time interval is set to apply. Backward movement can occur in both working status and non-working status. Because the frame identification is skipped with the time interval, backward movements is essential for accurate calculation of attendance when using the time interval variation. Therefore, when a time interval of a certain size is used without a backward check, inaccurate attendance data can be generated.

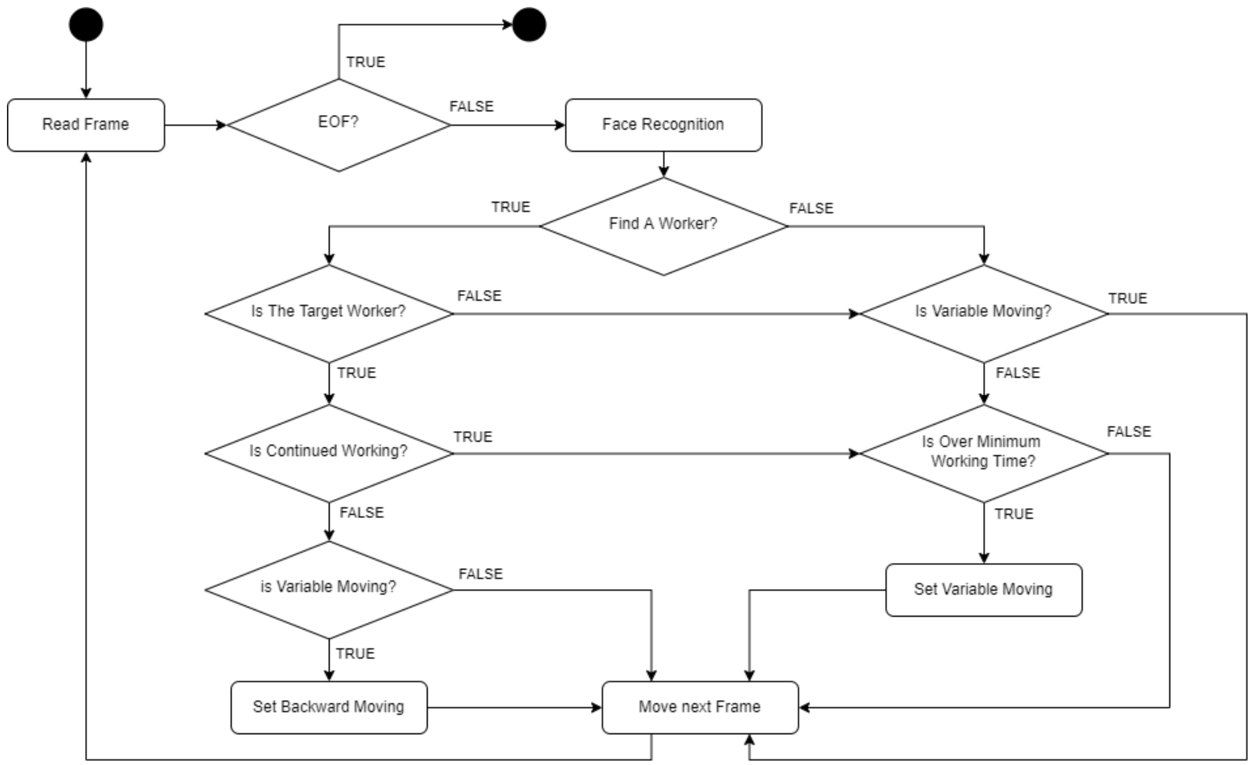
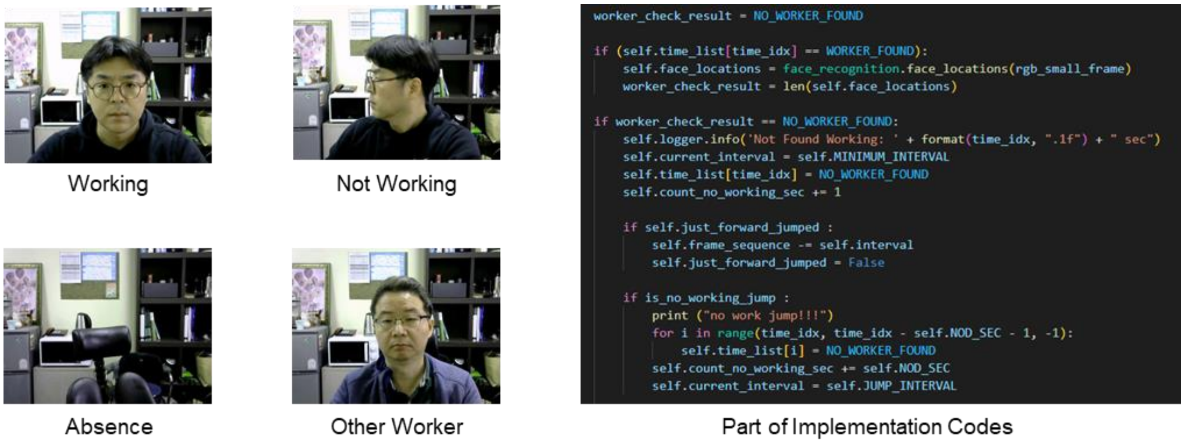


Figure 3. Time interval operation flow chart

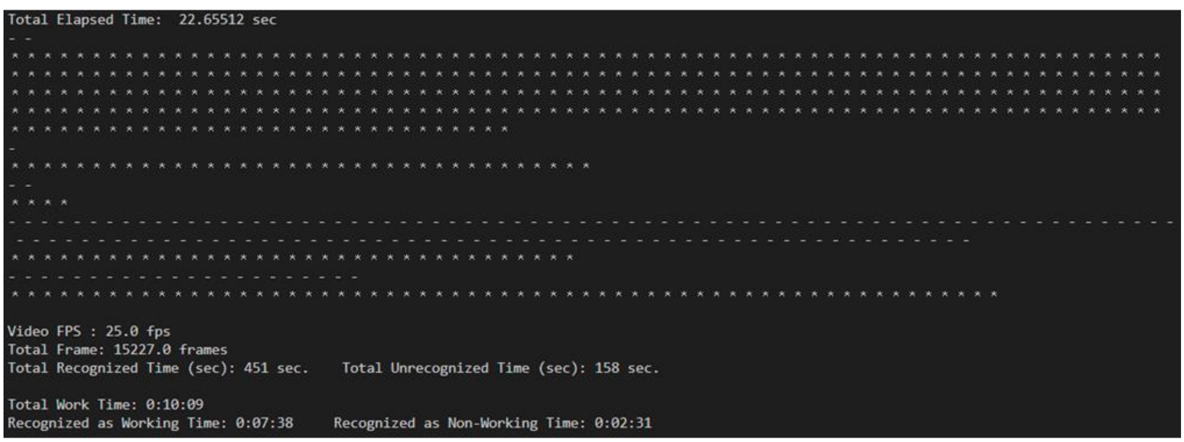
4. Case Study and Discussion

4.1 Case study

To validate the efficiency of the proposed model, a system for identifying face recognition video at variable time intervals based on the model was implemented. The system implemented using Python 3, and the face checker of the system used face_recognition [16], opency-python, TensorFlow, and Keras. The implemented system uses a worker's image to check the worker in the recorded attendance video and yields the working and non-working time data. Figure 4 shows attendance video samples, part of implementation codes, and sample of execution results. The attendance status of workers can be classified into working status, non-working status, absence, and appearance of other workers. Asterisks represents frames identified as working time, dashes represent non-working time. The value differences between Total Recognized Time and Recognized as Working Time can be occur whether status changes less than the minimum working time are reflected in working time. In the figure 4 (B), The non-working for 7 seconds in the working status. The system set the minimum working time to 15 seconds. So, it is identified as the same working status when a change occurs in working status in less than 15 seconds. For example, if a change in working status is returned to working after non-working for 10 seconds, it is identified as continuing status, and 10 seconds of non-working time is included in working.



(A) Working Status and Part of Codes



(B) Sample of Execution Result

Figure 4. Case study

A comparison was performed to validate the system based on the model. The same video was analyzed between the 1-second basic time interval system and the implementation system of the proposed model, and the execution time and accuracy were compared. The accuracy was measured by the difference from the basic system. The reason for the compared system uses a face recognition with a 1-second time interval is that as the time interval increases, differences occur due to skipping of the recognition frame. The comparison was performed on 4 videos of 10, 30 minutes, and 1 hour, respectively. Figure 5 shows the comparison results.

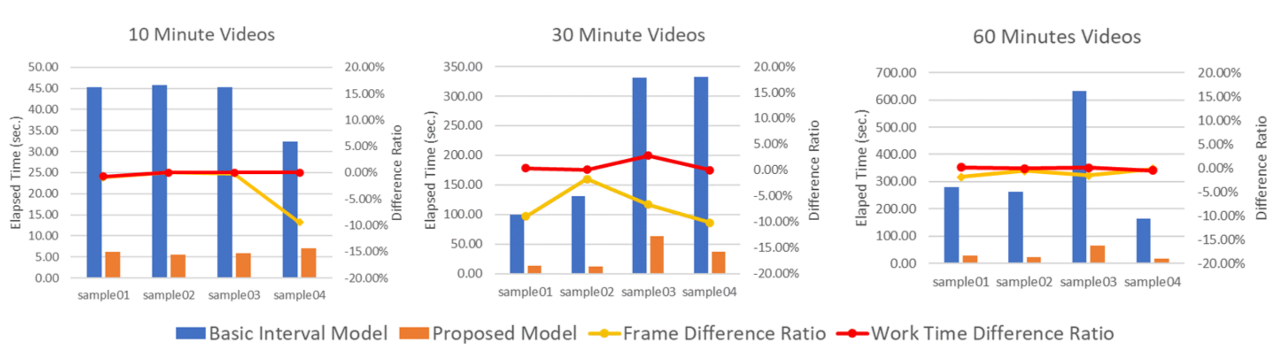


Figure 5. Comparison result

As a result of comparison, the system based on the proposed model was able to complete the search within 9% ~ 22% of the basic interval search time regardless of the length of the target video, and the accuracy of working time was also at least 97% and maximum 100% compared to the basic time interval system.

4.2 Discussion

In the case study, the basic time interval system checked frames only with the absence without minimum working time, so the difference of number of frames occurred in the proposed model, but it was validated that the difference was insignificant in the calculation results of working time. The implemented system based on the proposed model performs more faster than the fixed time interval method, and the accuracy was close to the minimum time interval method.

Through the implementation of the proposed model, we verified the model has a faster processing and the high accuracy to identify attendance data. The size of the time interval is proportional to the search speed improvement and inversely to the time estimation accuracy. The proposed model uses a fixed size of time interval which is minimum working time. But we can consider which a method of changing the time interval by gradually increasing or decreasing by the attendance status changing. In the case of videos with little change in attendance status, the time interval can be continuously increased, so that faster analysis can be performed. Also, we can consider that a method of improving the speed by reducing the number of backward moving by applying various time intervals according to the continuous attendance status.

5. Conclusion

With the spread of the untact work environment, the attendance management system using face recognition is being studied. We proposed a search model that performs fast searching using the time interval variation in the face recognition-based attendance system. The model can perform more fast identification attendance data by time interval variation, and more accurate analysis by backward moving to find the frame of attendance status changed. The implementation of proposed model performed at least 4.5 times faster than all frame identification and showed at least 97% accuracy. Since attendance management system analyze many videos with long lengths, applying the proposed model can be expected that more fast analysis time and high accuracy.

It is necessary to study models which extend variable time intervals related on the context of video, and it is necessary to specify classification of attendance status of face recognition data to provide detailed attendance data.

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