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Effectiveness of utilizing meta attributes in anomaly detection using crowdsourcing

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***Abstract*—In recent years, the clearance rate for crimes has remained low. One of the reasons for this is that it is difficult to clear crimes based on after-the-fact reports from surveillance cameras. Increasing the clearance rate requires manpower to constantly monitor surveillance cameras. Crowdsourcing is one way to secure manpower, and anomaly detection using crowdsourcing has already been proposed. However, anomaly detection using crowdsourcing has a problem in that the accuracy rate decreases in challenging tasks. Challenging tasks are tasks in which it is difficult for crowdworkers to determine whether there are anomalies. In this study, we evaluate the improvement of response accuracy in challenging tasks by using crowdworkers' response time and confidence in their answers as meta-attributes.**

***Index Terms*—crowdsoursing, anomaly detection, meta attributes**

I. Introduction

In recent years, the number of surveillance cameras has been increasing due to the availability of low-cost surveillance cameras because of the widespread use of the IoT (Internet of Things). However, the increase in the number of surveillance cameras does not necessarily mean that the crime arrest rate has increased, and the crime arrest rate remains at a low level [**?**]. This reason is that even when crimes are recorded by surveillance cameras, arrest fleeing criminals based on recorded video evidence alone is difficult. To increase the crime arrest rate, a system to detect and report crimes from surveillance camera videos is needed.

Itano et al. propose a system for detecting anomalies from surveillance cameras and generating alerts, utilizing a method that involves crowdworkers [2]. Their approach demonstrates the feasibility of achieving automatic, high-precision, and cost-effective anomaly detection. However, the drawback of their method is that the crowdsourced videos are unprocessed and require more time for crowdworkers to respond, resulting in inefficiency.

In our previous research, we evaluated the impact of changing the playback speed of videos provided to crowdworkers on accuracy and efficiency [3]. This research demonstrated that, in the case of videos with anomalies, increasing the playback speed led to higher accuracy and efficiency. On the contrary, for videos without anomalies, increasing the playback speed resulted in lower accuracy and efficiency compared to the findings of Itano et al.'s research. The results reveal that increasing playback speed decreases accuracy and efficiency in challenging tasks that are difficult for worker to distinguish. Challenging tasks are tasks in which it is difficult for crowdworkers to determine whether there are anomalies. This is evident as even at the standard playback speed (1x), the response accuracy was lower. Therefore, in anomaly detection tasks conducted by crowdworkers, there is a need to improve the accuracy of challenging tasks.

In this study, we aim to improve the accuracy of challenging tasks that are difficult for worker to distinguish. in anomaly detection conducted by crowdworkers by using the meta-attributes of these crowdworkers. Meta-attributes refer to supplementary information about responses, such as the crowdworker's track record, confidence score, response time, and other relevant details. By utilizing meta-attributes, our objective is to improve the accuracy of challenging tasks. We conduct evaluation experiments of the proposed method, focusing on accuracy. This study contributes in the following ways:

- We demonstrated the effectiveness of using the meta-attributes of crowdworkers to improve the accuracy of challenging tasks in anomaly detection.
- We demonstrated that utilizing response time is more effective in improving accuracy compared to methods that utilize confidence scores in responses.

II. Related research

A. Anomaly detection method using crowdsourcing

In our previous research, we evaluated the impact of changing the playback speed of videos provided to crowdworkers on accuracy and efficiency. This research demonstrated that, in the case of videos with anomalies, increasing the playback speed led to higher accuracy and efficiency. On the contrary, for videos without anomalies, increasing the playback speed led to lower accuracy and efficiency compared to the findings of Itano et al.'s research. The results reveal that increasing playback speed decreases accuracy and efficiency in challenging tasks. Challenging tasks are tasks in which it is difficult for crowdworkers to determine whether there are anomalies. This was evident as the accuracy of crowdworkers' responses remained low regardless of the changes in playback speed. Therefore, in anomaly detection tasks conducted by crowdworkers, there is a need to improve the accuracy of challenging tasks.

B. Method using confidence level

Oyama et al. demonstrated an improvement in accuracy by utilizing crowdworkers' confidence in their own responses when collecting answers through crowdsourcing [4]. Their method involves adjusting the weight of a crowdworker's response based on their confidence scores. For example, when a crowdworker expresses high confidence in their response, that answer significantly influences the result. Conversely, when the confidence score is low, the contribution of that answer to the result is diminished. By having crowdworkers self-report their confidence scores, they showed a positive impact on accuracy. This study showed the effectiveness of leveraging meta-attributes such as crowdworkers' confidence in enhancing response accuracy. However, Oyama et al.'s study was limited to specific conditions, such as image classification tasks and tasks involving general knowledge. In general, image classification tasks and tasks involving general knowledge are considered easier than anomaly detection tasks. Therefore, it is necessary to verify whether the use of meta attributes is effective even in anomaly detection tasks, which are more difficult tasks. The effectiveness of meta-attributes other than confidence is also evaluated.

III. Proposed method

In this study, we evaluate the effectiveness of improving response accuracy in challenging tasks by using crowdworkers' response time and confidence score in their answers as meta-attributes. As a method of using meta attributes, it is to quantify the time of the crowdworkers and the confidence in the answers of 0 to 100, and change the weight of each crowd according to the number. For example, if you want to change the weight of the answer depending on the response time of the crowdworker, use the calculation shown in Equation (1). Here, w_j is the weight of the response of the target crowdworker, t_j is the response time of the target crowdworker, and n is the number of crowdworkers to which the task is requested.

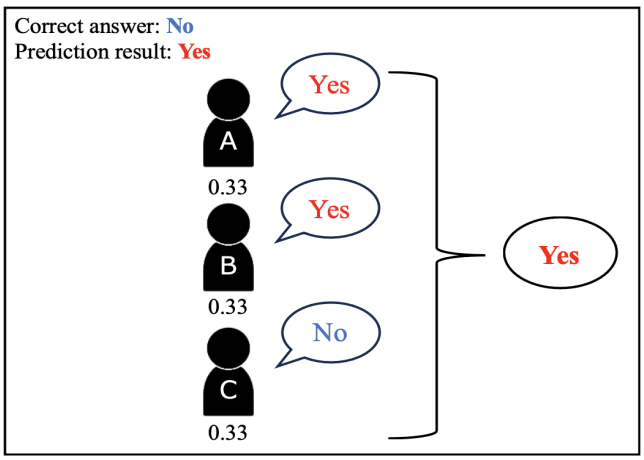

Fig. 1. Collecting answers by majority vote

$$w_j = \frac{t_j}{\sum_{i=0}^{n} t_i} \tag{1}$$

Also, when changing the weight of an answer depending on the confidence score of the answer, it can be expressed by calculations such as Equation (2), similar to Equation (1). Here, c_j indicates the confidence score of the target crowdworker's answer. $w_j = \frac{c_j}{\sum_{i=0}^{n} c_i}$ (2)

By calculating the equations (1) and (2), we can expect to improve the accuracy of the answers by changing the weight of the answers depending on the response time and confidence of the crowdworkers. For example, consider majority voting, which is often used when collecting responses through crowdsourcing, as shown in Fig. 1. When the sum of the weights of each crowdworker's answers is 1, the weight of each answer is 0.33, which follows the assumption that all crowdworkers have the same ability. However, in cases where there are large differences in the ability and sincerity of crowdworkers, such as in a crowdsourcing environment, it may be necessary to change the weight of answers for each crowdworker. Therefore, we believe that answer accuracy can be improved by changing the answer weight for each crowdworker as shown in Fig. 2. and 3.

IV. Evaluation experiment

A. Experimental method

In this study, similar to the previous study by Itano et al., we used UCF-Crime Dataset[1] as the dataset for anomaly detection. I do. The dataset consists of 950 normal videos and 950 abnormal videos, and the abnormal videos include 13 major types of abnormalities (abuse, abuse, (arrest, arson, assault, accident, robbery, explosion, fight, burglary, shooting, theft, shoplifting, vandalism). In this research, as a preliminary experiment, we will determine 10 video images that are

[1]https://www.crcv.ucf.edu/projects/real-world/

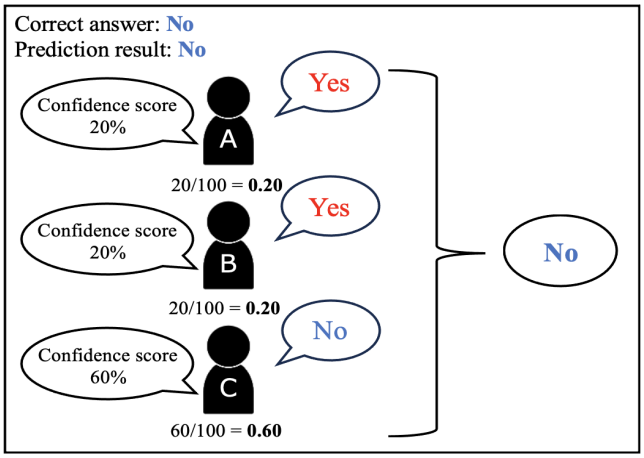

Fig. 2. Collecting answers using confidence score

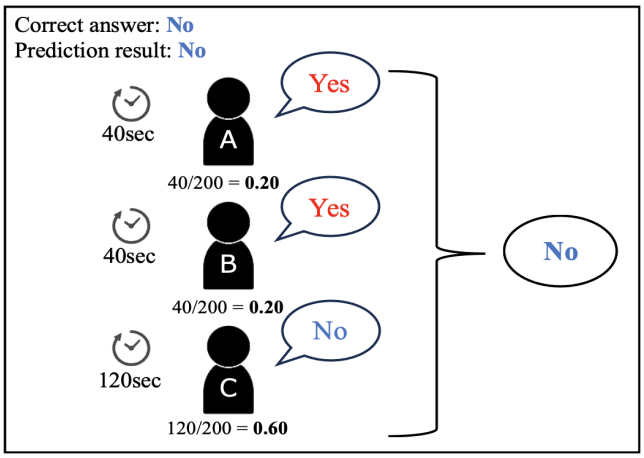

Fig. 3. Collecting responses using response time

difficult to judge from the UCF-Crime Dataset to be used in the main experiment. The 10 videos should include 5 videos with anomalies and 5 videos without anomalies. In this experiment, we use the 10 videos determined in the preliminary experiment to evaluate whether the use of meta-attributes is effective in improving anomaly detection accuracy. In accordance with previous research by Itano et al, the length of the video used in preliminary experiments and the length of the video used in main experiment was set to about 10 seconds.

In this research, we use Amazon Mechanical Turk (AMT)[2] as a crowdsourcing platform. AMT has more than 2,000 workers on standby at all times, and can ensure a certain level of real-time performance compared to other crowdsourcing platforms. Tasks given to workers can be freely arranged by writing instructions, videos, etc. in HTML or CSS.

B. Preliminary experiment

In a preliminary experiment, we used videos from the UCF-Crime Dataset, asked 10 crowdworkers to judge whether there were anomalies, and calculated the correct answer rate for each task. A video with a correct answer rate of 30% to 70% was set as a challenging video. We repeated trials until we found 5 challenging videos with anomalies and 5 challenging videos without anomalies. In main experiment, a total of 10 videos of 5 videos with anomalies and 5 videos without anomalies are used.

[2]https://www.mturk.com/

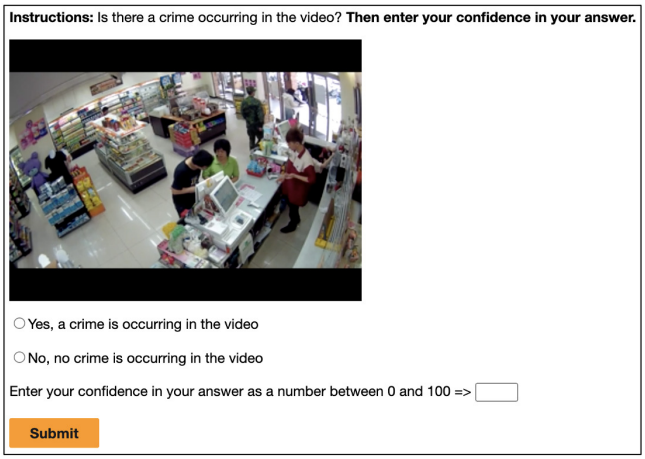

Fig. 4. An example of a task

C. Main experiment

In this experiment, we use 10 videos that are difficult to judge in preliminary experiments, and ask 10 crowdworkers to judge whether there is an anomalies in the videos. We created a task as shown in Fig. 4. for one video. Then, we conducted 50 experiments(5 experiments for each video) to ask 10 crowdworkers to judge whether there was anomalies. Additionally, the workers' responses were collected using three methods: majority voting, approach utilizing confidence score, and approach utilizing response times, comparing and analyzing the result. In the task, the crowdworkers were prompted to answer whether there was an anomaly with a Yes/No response and simultaneously input a confidence score for their answer ranging from 0 to 100. From these response results, response times and confidence scores were collected. Equations (1) and (2) were used to compute the weight of each crowd worker's answer based on these response attributes. Using the calculated answer weights, all the crowd workers' responses were collected. In addition, "accuracy" is used as an evaluation index. Accuracy is the average of the correct answer rates for each task.

D. Experimental result

The experimental results are presented in Fig. 5. Comparing with the majority vote, it is evident from the experimental results that the accuracy has improved through the utilization of meta-attributes. Moreover, the approach using response times achieved higher accuracy compared to the approach using confidence scores.

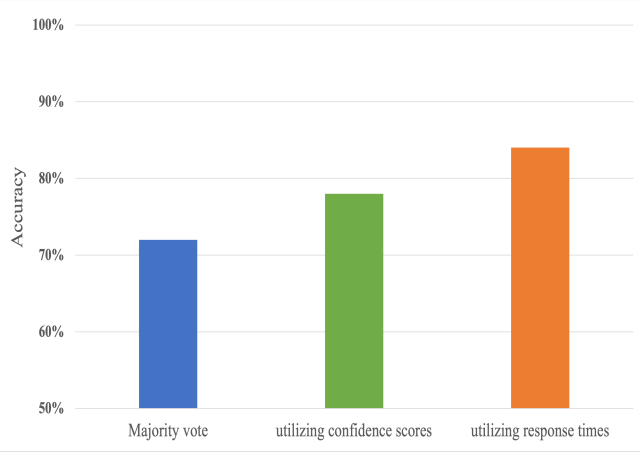

Fig. 5. Experimental result

E. Discussion

From the experimental results, it was evident that utilizing meta-attributes such as confidence scores and response times was effective in improving response accuracy when performing anomaly detection from challenging tasks through crowdsourcing. In this study, as we couldn't obtain videos with accuracy rates between 0% and 30% in the preliminary experiment. Thus, a video of accuracy rates of 30% to 70% was used as a video that was challenging. However, since we didn't assess the effectiveness of this method for images with an accuracy rate of around 0% to 30%, it's essential to verify whether this approach is effective for tasks that are even more challenging with lower accuracy rates in the future.

V. Conclusion

In this study, we evaluated whether the use of workers' meta-attributes is effective in improving the response accuracy of challenging tasks in anomaly detection by crowdworkers. As a result, we found that the use of meta-attributes is more effective than majority voting, which is commonly used when collecting responses through crowdsourcing. The results also showed that a method that utilizes response time leads to improved accuracy than a method that utilizes confidence in answers. In the future, we will need to work on improving the accuracy of anomaly detection tasks, which are more difficult to determine and have an accuracy rate of 0% to 30%.

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