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CCTV EFFECTIVENESS STUDY

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ABSTRACT

The field of CCTV surveillance is topical and widely used in many different applications. The fundamental part of the CCTV system is a reliable image evaluation by a human observer, whose effectiveness is influenced by many variables. Optimization of the effectiveness is a multidimensional problem related to both technical and human characteristics. In many applied systems the overall performance is affected by a real performance of technical system (image compression, channel transmission, etc.). On the other hand these technical systems have different optimization criteria than a typical video system.

TNO Defence, Security and Safety (formerly the TNO Physics and Electronics Laboratory) initiated a project in which the influence of several technical variables on the operator's effectiveness was studied. The whole project was carried out in close co-operation with the Czech Technical University in Prague (CTU). The paper demonstrates and summarizes selected experimental results and evaluated dependencies.

1. INTRODUCTION

The field of CCTV surveillance is topical and widely used in many different applications such as a town centre surveillance. The fundamental part of the CCTV system is a reliable image evaluation by a human observer, whose effectiveness (i.e. incident detection rate) is influenced by many variables. Optimisation of the effectiveness is a multidimensional problem related to both technical and human characteristics. On the technical side, it is important that the modern technology is applied properly. Of the human characteristics, operator skill and motivation are decisive. Even if the system technical performance is excellent, the crucial element in the chain is the human observer. The quality and pre-processing of video information, manner of presentation and working environment strongly influence the operator's effectiveness.

TNO initiated a project in which the influence of a few technical variables on the operator's effectiveness was studied. The project consisted of two parts. The first part involved the recording of enacted incidents, like bag snatching, harassment, etc, and assembling the recorded scenes onto the test-tapes for viewing by a number of selected test-persons. In the second part, the tapes were viewed and the test-persons' incident detection rates were noted. The evaluations were carried out by as many people as possible to obtain statistically relevant results.

The whole project was carried out in close co-operation with the Czech Technical University in Prague (CTU). The Haaglanden Police, the regional police force situated in The Hague, generously provided valuable knowledge of criminal behaviour and supplied actors from the police dramatic society Dindua for the incident recordings. The test-tape evaluations were carried out by students of the Prague Police Academy (under supervision of CTU) and by CCTV-operators of the Haaglanden Police (under the supervision of TNO). All test-persons had experience in law enforcement. To exclude CCTV operator skill as a variable in the evaluations, extremely skilful and extremely unskilful test-persons were removed from the group based on their SAMAE score. SAMAE is a PC-based operator evaluation tool, which was kindly made available for this project by the South African company Leaderware.

2. RECORDING OF THE INCIDENTS

All recordings were conducted close to the railway station 'Den Haag - Hollands Spoor'. Around this station the city council has recently installed a high quality camera observation system. Pictures are sent by means of fibre optics from the cameras to the police control room about 1 km away.

In front of 4 cameras numerous police officers staged a large number of incidents. The incidents were recorded on 4 digital recorders in the control room. The recordings were made on December 14 and 19, 2002, and on January 15 and 18, 2003. Preceding these recordings, a

number of test recordings in front of one of the cameras was made on September 21, 2002. Two of the locations are shown in Fig 1a,b.

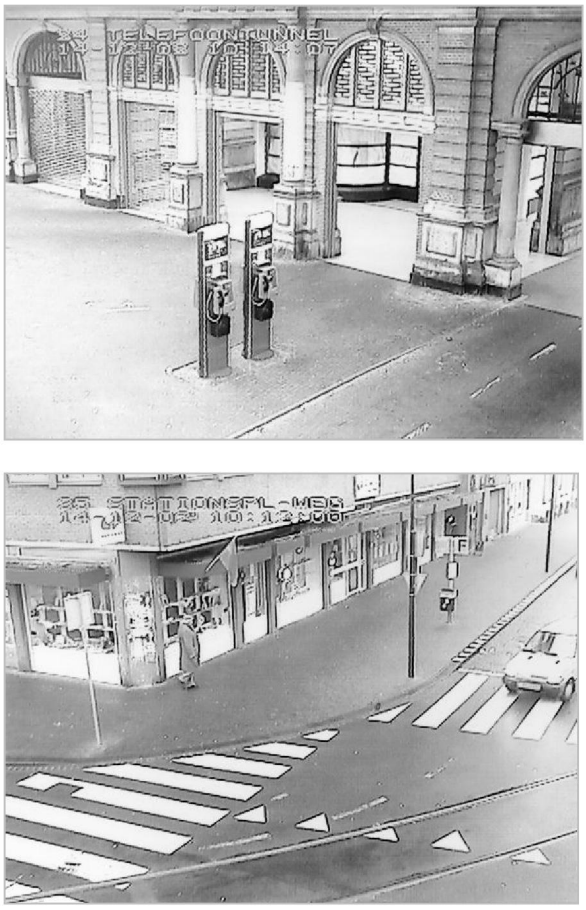


Fig.1a,b: Examples of scenes

All recording days were carefully prepared and the actors were extensively instructed. In total, the following recordings were made:

1) Staged incidents:
   a) 37 bag- or cell-phone snatching incidents,
   b) 33 threatening or harassment incidents,
   c) 20 appearances of the same missing/wanted person,
2) Uninterrupted background recording, before, in-between and after the staged incidents.

Each incident was conducted with different actors or actors with different disguises. In total, 26 actors were involved.

A number of aspects of each enactment was kept as constant as possible, to acquire valid operator statistics, e.g. the duration of the actual bag-snatch, the robber's action after the incident, the duration of the robber's exit after the incident, etc.

In order to avoid habitual incident recognition by an operator, extra variances were added to the enactment, e.g. distance to the camera was varied slightly, angle to the camera was varied over the full range, appearance of the actors (as many different actors as possible were used, or actors were 'used' more than once but changed their appearance, etc.).

One of the played incidents is shown in the (partial) image in Fig.2.

Fig.2: Example of incident

3. STRUCTURE OF TAPES

From the recorded data, a number of evaluation tapes was assembled, each having a structure as shown in Fig. 3. Each tape consisted of 24 clips of 5 minutes, and comprised a number of randomly distributed incidents, completed with non-incident clips. During the assembling, special care was taken to keep the transitions between the clips as smooth as possible (e.g. only small differences in the number of people in the scenes).

There is a great number of variables which might influence the effectiveness of an operator. A number of these variables was taken into consideration in a preceding test phase of the project. For practical reasons, only a limited number of variables could be evaluated within the project. For the first part it was decided to choose the frame rate and the image brightness as the variables of which the effects were to be investigated. The frame rate had values of 25, 2 and ¼ f/s, while brightness had values of 100%, 50% and 20% of maximum value. The number of monitors which an operator had to observe at the same time, was the third variable to be investigated. For this purpose, tapes (with the original frame rate and brightness) were re-edited for viewing on 1, 2 and 4 monitors simultaneously.

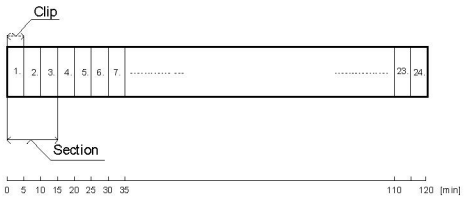


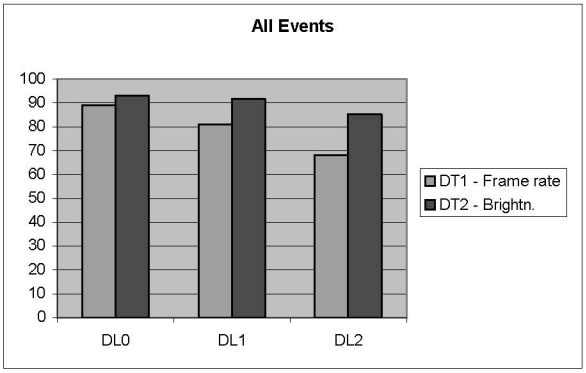
Fig.3: Structure of tape

4. EVALUATION OF RESULTS

The first two variables (frame-rate and brightness) were evaluated having an operator looking at just one monitor in a studio at CTU; the effect of the last variable (number of monitors) was evaluated in the CCTV control room of the Haaglanden Police in The Hague. Each evaluation session took 2 hours, excluding an introductory session, a training session and the SAMAE tests. The SAMAE test results would also be used to investigate the correlation between the SAMAE software and the actual evaluation results (i.e. to determine the program ability to predict an operator's level of skill). In total, 88 2-hour single monitor evaluation sessions with 22 students of the Prague Police Academy were carried out at CTU. In The Hague 35 sessions, with 16 CCTV operators were conducted. All results were collected in Excel sheets. The significant amount of data has still to be analysed in detail. It is our intention to publish the second part of this analysis at the 40th Carnahan Conference next year.

A few preliminary conclusions could already be drawn from the single monitor evaluations:

1. The detection probability seemed to remain rather constant (and rather high) during most 2-hour sessions, i.e.: '2 hours of constant concentration for single monitor watching is feasible for a motivated operator', or, 'the level of distraction was too low, both during recording (small number of objects in the scene) and during the evaluation sessions (other people in the room)'; a few strange effects were noticed.
2. Although much care was taken to keep the incident enactment similar, distinct differences were noticed. To correct for this unwanted effect, it was decided to assemble a new tape containing all incidents and have this tape shown to a couple of experienced policemen/operators for their judgement of each incident's 'detectability', e.g. on a scale of 0-10. These figures will then be used as weighting factors to the operators' scores.
3. The influence of frame rate and brightness reduction was clearly visible in the detection probability scores.



Tapes were shown in 88 2-hour single monitor sessions, involving 22 different test persons. The results are illustrated in Fig. 4.

Fig. 4: Single monitor evaluation results

The figure shows the score as a percentage averaged over 22 test persons for the different values of the frame rate (Distortion Type 1) and the brightness (Distortion Type 2). The horizontal scale refers to the different Distortion Levels. DL0 corresponds with the original version, DL1 with a lower frame rate and brightness, DL 2 refers to the lowest frame rate and lowest brightness. As could be expected, the score decreases as the images become poorer, although rather gradually. It should be mentioned that the relatively high scores are partly due to the test persons' heightened state of concentration and does not necessarily represent common practice in operational CCTV control rooms. Most of the test persons felt it as a competition and wanted to perform better than their colleagues. The figure shows also that the influence of decreased brightness is hardly significant: people remain capable of recognizing events, even in worse light conditions.

The results in Fig.4 include all three types of events. One might wonder if there are significant differences in the scores for the three types of events: e.g. Fig.5 reflects the separate scores for the third mentioned type of event (i.e. appearance of the same suspect person in the image).

Fig. 5: Single monitor evaluation results

At the beginning of the project, it was thought that an operator, watching the images for as long as 2 hours on end, would loose some of his concentration in the course of time and hence should show more undetected events towards the end. This effect could not be confirmed convincingly in our tests. Apparently the test persons could keep a high concentration for the full 2 hours.

Figs.6,7 show the results of the multi monitor evaluations, carried out by 16 test persons where DL0, DL1 and DL2 represent 1, 2 and 4 monitors respectively. The vertical values are averages, and include all three types of events.

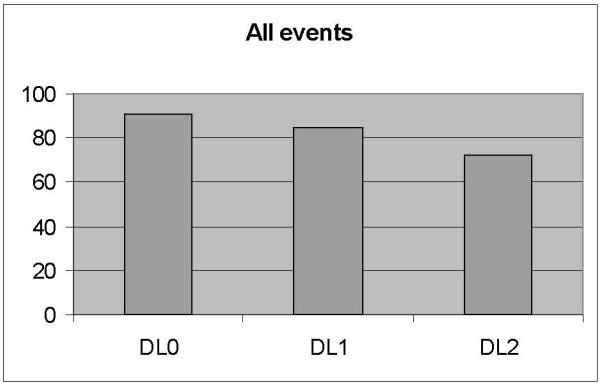


Fig.6: Scores for different number of monitors

As the tests were very time consuming, and as it soon became apparent that the single and 2-monitor evaluation scores would be very high, attention was turned to conducting relatively more 4-monitor tests. The 4-monitor test was carried out by 16 operators, the 2-monitor test by 6 and the 1-monitor test by 10 operators. All operators complained that the 4-monitor test was very hard, but all persevered to perform as good as possible. The average scores were 91%, 85% and 72% respectively. There were relatively great differences between the individual operators; Fig.7 gives an impression.

Fig. 7: Individual scores for 1, 2 & 4 monitor sessions

8. CONCLUSION

This paper summarizes the first part of results of the CES-1 project. Presented dependencies demonstrate the initial set of results related esp. to the number of monitors. The data processing is in progress and we plan to present the second part of the results at the 40th Carnahan Conference.

Among many other parameters it seems to be fundamental to include some additional psychological aspects. Presented scenes are very tedious and boring and some slightly exciting events can help to keep the attention. On the other hand occasionally numerous distracting objects and events can appear causing the scattering of attention. Both of these effects have been studied and some generalized conclusion will be really valuable in order to optimize the watching period length of operator.

11. REFERENCES

[1] Klima M., Pazderak J., Bernas M., Pata J., Hozman J., Roubik K., Objective and Subjective Image Quality Evaluation for Security Purposes, 35th IEEE International Carnahan Conference on Security Technology, London, U.K., 2001