HF Guidelines for CCTV supervision in control centres.

Phase II Research Proposal (June 2013)

Abstract

CCTV-operator tasks can be found for a variety of applications, such as surveillance, security, traffic supervision, tunnel safety, and remote (process) control. A limited number of Human Factors Guidelines is available for surveillance (security) and traffic systems. The evidence level of these guidelines is low and other CCTV applications are not discussed.

Early 2012, a research project *Human Factors of CCTV in practice* (Phase I) was initiated, aiming at the development of Human Factors Engineering guidelines for CCTV-related operator tasks. Besides traditional (full time) surveillance and traffic supervision, interest was also aimed at remote process control and object control. May 2013, Draft HF guidelines have been compiled. However, several well documented questions remained unsolved. This document summarizes these unsolved questions and proposes further research.

The project has been supported by 17 organizations with an active interest in CCTV control centres. Project Phase II is now open for new partners.

1. Introduction

A CCTV-system (Closed Circuit Television system) is a human-machine system, consisting of an observed reality, cameras, transmission, displays, image presentation, workplace(s), and operator tasks including cognitive information processing. CCTV is used for traffic supervision, tunnel safety, object control (lock and bridge control), surveillance, security, remote process control, and so on. Regarding traffic supervision or surveillance, dedicated centralised control rooms emerged over the past decades. More recently, also remote process control (industrial control related applications) can be found. Contrary to typical surveillance tasks, process control related use of CCTV may not be a full time operator job, i.e. there will be other tasks.

There are well established Human Factors (HF) guidelines available for control centre design in general. Refer to the ISO11064 series on ergonomic design of control centres. However, CCTV is hardly mentioned. An overview and first attempt to give generalised guidelines was presented by Wood (2007). Based on the observation of a lack of knowledge and being involved in control centre design projects, ErgoS initiated a research project ***Human Factors of CCTV in practice***. Research partners and 13 supporting organizations were found. The project objective was to assess the State-of-the-Art on Human Factors of CCTV systems and to promote HF improvements in CCTV control centres.

The leading research question of the project has been:

***What should an operator be able to see, detect, or read reliably on CCTV images? And therefore, what HF requirements should be met by the CCTV system*?**

The project consisted of 4 phases:

1. Orientation and review of published guidelines and literature.
2. HF analyses in 8 CCTV control centres, in order to gain insight in relevant CCTV tasks.
3. Field and laboratory experiments on image quality and the number of images an operator may be able to observe reliably.
4. Development of Draft Guidelines.

The scope of the project was limited to digital CCTV-systems and did not include legal and privacy related topics. The project budget enabled 160 days of research efforts.

2. Phase I - Research results

2.1 Literature review

Forty publications on Human Factors of CCTV systems have been found and reviewed (Schreibers et.al, 2012). Overall, the HF literature on CCTV is limited, not counting papers on privacy aspects or legal matters, and studies on how the public responds to CCTV. Very few references were found to remote control tasks, such as lock and bridge control, loading & unloading supervision, and the control of remote process units (unmanned plants, oil and gas production sites).

Generally speaking, design guidelines are limited to listings of "things you should think of while designing CCTV control centres". Some remarks:

- There is no guidance on large screen display technology and videowalls.
- It is stated that the number of images (live streams) an operator can handle depends on task complexity. Some sources mention actual data, i.e. a maximum of 12 to 16 images for low task complexity, however task complexity is not being defined.
- Operator workload is usually given as the camera/monitor-ratio or the number of screens per operator. This guidance is not task related and in addition highly dependent on display technology.
- Evidence seems to be rather thin: only a few laboratory experiments have been reported. A small number of field studies has been published, in particular from the UK (Wood, 2007) concerning traffic control (checking hard shoulders for objects), rail safety (level crossings), and incident detection in shopping areas.

2.2 Case studies

The previous considerations have led the research team to carry out eight case studies into CCTV work situations. Each situation has been analysed systematically by experienced ergonomists using a standardised analysis protocol. The situation at hand was recorded in drawings and photographs. Task performance was observed and semi-structured interviews with operators were held. Each situation was visited during two days. Cases included tunnel traffic supervision, two security control centres, tankage terminal remote supervision, a maritime application, and lock control.

Figure 1. Case: remote lock control

Figure 2. Case: traffic supervision.

2.3 Pilot experiments

Surprisingly, there is not much published scientific research on image quality reduction due to coding, transmission, decoding, and scaling of images. Test charts and test procedures have been developed by Aldridge & Gilbert ("Rotakin manikin"; 1996) and Damjanovski ("Vidilabs test chart", 2005). Image quality is linked to a topology of the following tasks: monitor, detect, recognise, and identify. This topology concerns persons on images. It is expected that this topology will not hold for functions in a (process) control setting. Generally speaking, we noticed two opposite areas of interest:

1. Surveillance systems
   Research focusses on image reduction in view of a limited transmission capacity relative to a large number of camera views one would like to transmit.
2. Other application areas, where image reduction and quality degradation are not an issue, because (mainly) lossless systems are assumed.

The findings from literature on image quality have led to pilot experiments regarding the use of test charts. In a laboratory setting mediated (camera - transmission - display) images and non-mediated images (direct view) have been compared for a test chart, Rotakin manikin, and a Landolt C visual acuity test chart. Preliminary results:

- The Rotakin test allows the subject to develop strategies to determine correct answers, by-passing the actual image quality. Therefor, this test is considered to be not very useful.

- Scores on a Landolt C test for non-mediated images are significantly better than for mediated images.

Figure 3. Three test conditions for Landolt C, Vidilabs and Rotakin test charts.

3. Draft Guidelines

At the end of Phase I, Draft HF Guidelines have been compiled. The guidelines are intended for use in a technical project environment. The structure of the related ISO standard on the design of control centres (ISO 11064) has been adopted. An overview of the content:

1. *Project Ergonomics - the engineering process*
   General approach to integrate HF in the design of CCTV-related control centres, giving guidance to the engineering process and HF activities.
2. *System Description*
   Describes the elements of the CCTV system and how to achieve a complete description including a detailed information analyses.
3. *Tasks and jobs*
   CCTV operator job content, workload, and work organization issues.
4. *Control centre layout and workplace design*
   Requirements for control centre layout, workstation design and visual anthropometry for situations with a large number of information displays. Here, hardware is considered; software issues are covered in Chapter 5.
5. *Image presentation and interaction design*
   For CCTV systems, the majority of information concerns camera "images". This chapter includes guidelines on information (i.e. image) display, image quality, navigation (image hierarchy and selection), and picture design including hybrid graphics (images and other types of information).

4. Research proposal

Several blank spots have been encountered during phase I.

- We have found contradictions between case studies and literature. For example, in several case studies, the number of CCTV images presented to one operator is considerably larger than the 12 to 16 images guideline found in literature. Users don't seem to have a problem with this.
- Experiments are needed to understand better factors influencing image quality. Also of interest would be to verify the validity and practical use (instructions) of test charts.
- Related to the previous point, image complexity is not clearly defined. For example: does movement within images contribute to the level of complexity? How does image complexity relate to operator mental workload?
- To describe the content of CCTV-images, a new concept has been introduced. A **scene** is a logical and meaningful **set of visual information**, to be monitored with a specific aim. It is expected, that the concept of **scenes** will be useful to address CCTV task complexity. This concept might replace the traditional task complexity variables "camera-operator ratio" and "camera-monitor ratio". The operator task determines the composition of a scene. This idea is broadly supported by the Phase I project partners.
  A constructed example to illustrate this: for tunnel safety monitoring a series of images representing one traffic direction could be one scene. Maximum operator workload for the monitoring task could correspond to four tunnel tubes. Once an incident occurs, the scene changes towards detailed images of the incident area. For serious incidents, workload may become high and a colleague is asked to monitor the remaining tubes.
- Task complexity is related to operator education, training, and experience. The case studies showed large differences; an impact on guidelines for task complexity, information structuring, and so on, should be expected.
- It should be considered to address HF aspects related to automated video content analytics (VCA), post-event analysis of CCTV footage, special Infra Red and/or very high resolution cameras.

Research proposals - Work packages for Phase II

We envisage 3 Work packages for Phase II research.

- WP 1 - Scene Development
- WP 2 - Image Quality & Task topology
- WP 3 - Document Upgrade and systematic Guideline Feedback.

Work Package 1. Scene and task complexity

- ***Aim***
  - To develop a theory for the concept of a scene, as a tool to analyse task complexity. A scene is a logical and meaningful set of visual information, to be monitored with a specific aim.
  - To develop guidelines on the number of scenes an operator can handle.
  - To determine the relationship between task complexity and movement in images.

- ***How***
  - Review literature on factors determining image and task complexity, in search of experimental evidence of statements regarding complexity factors. Thus far, image complexity is not yet clearly defined.
  - Review the case studies (of project phase I), regarding:
    - factors determining task complexity, and image complexity
    - any workload indicators
    - additional analyses at the case study sites may be needed.
  - Develop a theory on how to identify a scene
    - check in practice: what did we find in case studies
    - develop a guideline and find evidence regarding the number of scenes per job by performing field experiments as well as controlled laboratory experiments.
  - Develop guidance on how to design scenes: i.e. the arrangement of images, need for stitching technology, etc.

- ***Product***
  Evidenced guidelines regarding scenes
  - number of scenes an operator can handle;
  - tested guidelines for structuring images within scenes
  - guidelines for designing reference graphics (graphics to support scene selection).
  - improved/new texts for Draft Guidelines.

- ***Cost - Amount work***
  A first estimate for this proposal would be 40 days of work.

Work Package 2. Image quality and task topology

- ***Aim***
  - Get a better understanding of the variables that influence experienced quality of CCTV mediated images.
    - what happens at pixel level during transmission and processing from camera to monitor.
    - compare mediated images and direct view (what are performance differences between direct view and mediated images).
    - what is the degrading influence of the camera environment, particular of light and lighting conditions (day/night, reflection hindrance, maritime situations).
  - To develop an evidenced test procedure on experienced image quality of CCTV mediated images.

- ***How***
  Laboratory experiments & experiments in a controlled settings/simulator settings. Experiments will follow-up on reported pilot experiments.
  - Validate Vidilabs, Rotakin and Landolt C methods / test charts.
    - A pilot experiment indicated that the Rotakin method is not valid for facial recognition. If so, substantial proof for this statement should be provided, because at this moment the method is widely used.
    - The Vidilabs chart and Landolt C approach could be integrated in one test tool and test procedure; to be validated for use in one or several CCTV application areas.
  - Test in a controlled setting (suggested: a simulator of tunnel traffic management system)
  - Verification of controlled setting outcomes by laboratory experiments (usability laboratory at HAN).

- ***Product***
  - Method & procedure for experienced image quality assessment in different areas of application. Choice of application areas to be based on situations which are relevant to the funding project partners. Suggested: surveillance/security, traffic control, maritime situations.
  - Improved/new texts for Draft Guidelines.

- ***Who***
  - Leading contractor: HAN University of Applied Sciences.

- ***Cost***
  Based on substantial contributions by students (level: last year of BSc) a total minimum cost estimate will be € 32.000.

Work Package 3. Document upgrade and systematic guideline feed back.

- ***Aim***
  WP 3 combines the need to get feed back on the current draft guideline, the incorporation of research currently going on elsewhere, and the results of WP 1 and WP 2. Hence, the aims are:
  - Organize feed back on the practical use of the Guideline document.
  - Improve the Draft Guidelines
  - Follow up on recently published literature, and research.

- ***How***
  - We are aware of several (international) studies going on. Results are not yet published or incorporated in standards or guidelines. It is proposed to actively seek contact with other research institutes in order to exchange knowledge and experiences.
  - Project partners will be involved in real world projects of CCTV control centre (re)design. Within WP 3 feed back should be managed, amongst others leading to an in depth improvement of guidelines.
  - The Draft Guidelines aim for all types of CCTV systems and therefor are general by nature. A differentiation towards application areas could be useful. The following approach is envisaged:
    1. Establish a general part of the CCTV systems guideline
    2. Include an updated version of the literature survey.
    3. Develop supplemental guideline documents for specific application areas. Depending on the interest areas of funding partners, the following areas are expected:
       - process industries, i.e. remote control of processes
       - health care, i.e. remote assessment of patient situations.
       - supplemental guides on special (new) technology.

    Note: several items of Work Package 3 can be developed into separate (additional) Work Packages.

- ***Product***
  Updated/improved Guideline Document.

- ***Costs***
  In order to be effective in the other Work Packages, a minimum effort on Work Package 3 will always be needed and is estimated at 20 days.

5. Project organisation and funding

An important feature of our research is the active participation of project partners. For Phase I they suggested the case studies and participated in four Workshops, giving valuable feed back to the researchers and exchanging information with each other.

Phase II (Work packages 1 - 3) are now open for participation. Again, each participant contributes a relative small amount to the project, and gets in return the results of a large scale research project, as well as participation in several Workshops, enhancing (internal) subject knowledge. Final decision to participate after agreement on the content of Work Packages.

Costs
We aim for the same level of contribution as in phase I (€ 8.000). In addition, new partners will be asked to contribute to the phase I results as well.
Because it is essential that each new partner is brought to the same level of knowledge and involvement as the Phase I partners, an in-company HF of CCTV workshop will be organized offered.
Universities or Research Institutes are also welcome to participate. Exchange of information and results will be of benefit to all partners. However, we expect other researchers to look for project funding, i.e. additional project partners.

Schedule
Based on a preliminary assessment of the number of Phase II participants, a detailed R&D proposal - i.e. Work Packages - will be drafted in June 2013.
Expected Phase II start: October 2013.
Based on first reactions, we can confirm that the project will continue at a level of at least 100 days of research efforts, plus additional student work.

Project structure and project partners

The research project ***Human Factors of CCTV in practice*** was based on participation and funding by 13 project partners with an active interest in CCTV-system design. The project has been carried out by four research partners with an extensive Human Factors (HF) knowledge on control centre design. For all inquiries please contact Ruud.Pikaar@ergos.nl (www.ergos.eu, +31 53 4280500).

Research partners

- ErgoS Engineering & Ergonomics (Enschede)
- ICA - Han University of Applied Sciences (Arnhem)
- Intergo (Utrecht)
- VHP HP (The Hague).

Project partners (2012-2013)

- H.I.T.T. Traffic
- IHC Dredgers / IHC Beaver Dredgers
- Nedap Security Management
- NS Concern safety, dep. Security
- ProRail ICT Services
- Royal Haskoning DHV
- Total E&P Netherlands
- Vopak Management Netherlands B.V.
- Waterschap Hollandse Delta
- DG-Organisatie Bedrijfsvoering Rijk
- Provincie Noord-Holland
- Rijksbelastingdienst.
- Rijkswaterstaat - DVS

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