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CASRA NEWSLETTER – ISSUE 4

In our last newsletter we highlighted the security area from another perspective and took a glance at security screening in a nuclear power plant. In this issue we continue this series of security in practice by looking at security screening in a Swiss prison.

Another area of high importance is cargo screening. In our second article we present a study in which a computer-based training for cargo screening was evaluated regarding its value for increasing detection of prohibited items in X-ray images of cargo containers and unit load devices.

With this newsletter we are pleased to provide some insightful reading for the upcoming summer days and hope that you will take interest in the topics. Have a lovely summer!

Prof. Dr. Adrian Schwaninger

Dr. Diana Hardmeier

TOPICS IN THIS ISSUE:

RESEARCH PUT ACROSS

INCREASING X-RAY IMAGE INTERPRETATION COMPETENCY OF CARGO SECURITY SCREENERS

In the past years, security measures were increased for passengers, while cargo security did not receive a similar level of attention. A terrorist attack in the field of cargo could highly impact the world's economy, commerce or the global supply chain. Therefore, container security, but also contraband interdiction in air cargo and cargo shipping are becoming highly relevant topics at ports and airports all over the world. X-ray screening of cargo plays an important role in the security chain. In this article a scientific study is presented which examined the value of computer-based training for increasing X-ray image interpretation competency of cargo screeners.

SECURITY IN PRACTICE

X-RAY SCREENING AT PRISONS

You are not allowed to bring your mobile phone, your camera, a USB stick or for instance some aspirin. This is the situation encountered by visitors to a prison in Switzerland and in many other countries. The complete list of prohibited items is much longer, but the examples already show that security controls in prisons are different to security controls at airports. This article illustrates how CASRA cooperates with experts and end-users to create efficient and effective computer-based training tailored to the area of application.

INCREASING X-RAY IMAGE INTERPRETATION COMPETENCY OF CARGO SECURITY SCREENERS

Text: Stefan Michel & Marcia Mendes

In the past years, security measures were increased for passengers, while cargo security did not receive a similar level of attention. A terrorist attack in the field of cargo could highly impact the world's economy, commerce or the global supply chain. Therefore, container security, but also contraband interdiction in air cargo and cargo shipping are becoming highly relevant topics at ports and airports all over the world. X-ray screening of cargo plays an important role in the security chain.

X-ray cargo screening for the inspection of unit load devices (ULDs) and containers is emerging quickly as a common feature at ports and airports. A big advantage of X-ray screening is that images of the contents of a ULD or container can be provided quickly, without causing any physical changes to the containers. But despite the advances in technology, the actual decision whether an X-ray image of a container or ULD (see Fig. 1 for an example) contains a prohibited item or not still needs to be taken by a human operator, i.e. a cargo security screener.

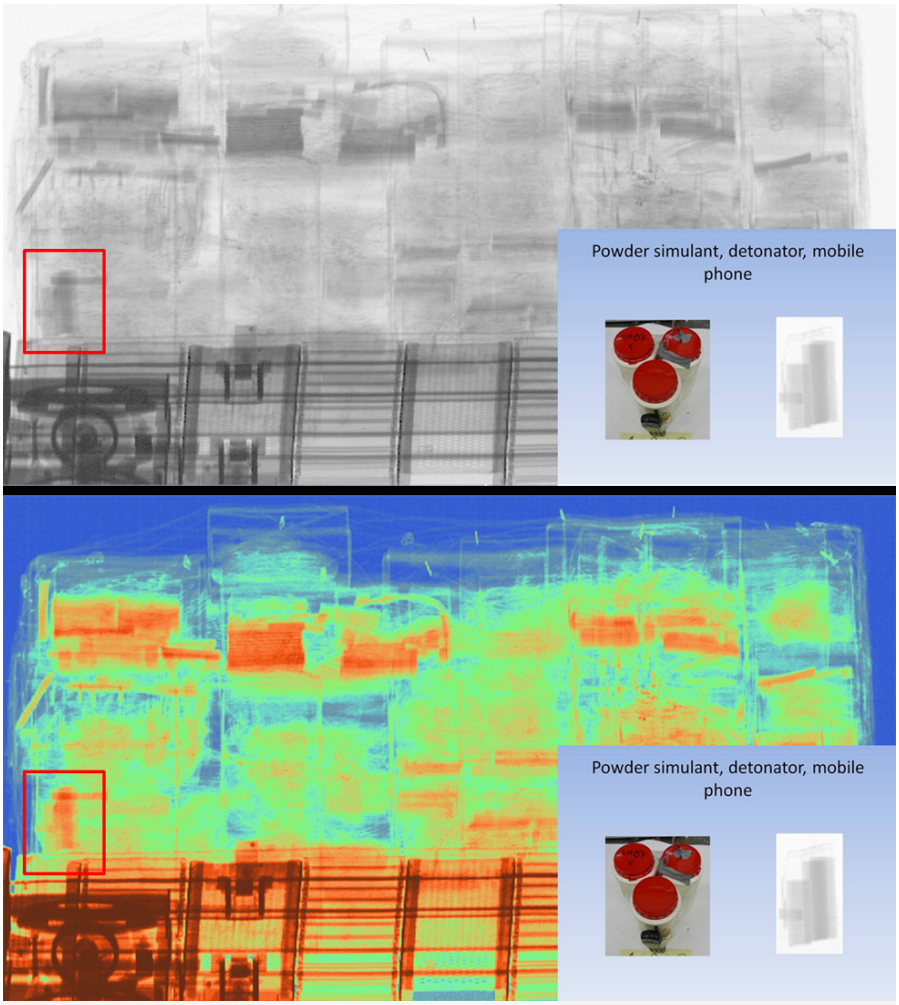

Figure 1: Example of the same X-ray image of a ULD, once in greyscale and once in pseudo colors

THE CHALLENGES OF CARGO X-RAY SCREENING

The interpretation of cargo X-ray images must be considered as an extremely challenging task. The large sizes of containers make it very difficult for the cargo security screeners to detect the proportionally small threat items (e.g. an improvised explosive device, IED) and contraband goods. Screening officers are expected to assess the contents of large containers or ULDs within a few minutes only. Therefore, it is essential to consider human factors in security screening and to support the decision-making of human operators, e.g. through training (e.g., [1], [2]).

Based on this, **a study was conducted to investigate whether X-ray image interpretation competency of cargo security screeners can be improved using a specifically designed computer-based training (CBT)**, including security and customs related items. In the areas of cabin baggage screening and hold baggage screening, CBT of X-ray image interpretation competency has been proven to be effective in previous studies (e.g. [3], [4]).

In cargo X-ray screening, the application of X-ray machines with dual energy technology is still difficult and costly. Dual energy technology results in color coded images based on the material in a bag or unit. Single energy technology, as it is in use in the field of cargo, provides greyscale images. As humans can only discern a few dozen

grey level values while they can distinguish thousands of colors ([5]), it could be assumed that the application of color would help to better distinguish objects. This is why single energy technology equipment usually features pseudo color (among others) as an image enhancement function that the screener can apply to the X-ray image. **We therefore also investigated whether showing the original greyscale image in pseudo colors (see Fig. 1) could improve the detection of prohibited items in cargo X-ray images.**

COMPUTER-BASED TRAINING FOR CARGO SECURITY SCREENERS

For the purposes of the study, X-Ray Tutor (XRT), a computer-based training system developed to enhance X-ray image interpretation competency ([6]), was adapted to the field of cargo X-ray screening (C-XRT). As opposed to other versions of XRT, where threat items are merged into clear bags by the software directly during the training session (see also issue No. 2 of this newsletter), training images were used where prohibited objects had been merged into images of clear containers beforehand (so-called combined threat images)[1]. During training with C-XRT, X-ray images were presented to the screening officers which they had to categorize as harmless (OK) or not (NOT OK). In case a ULD was judged as NOT OK, the screener had to identify the threat item by clicking on it. After each response, feedback regarding its correctness was provided. C-XRT allowed exposing screening officers to objects they usually do not encounter in everyday life (e.g., IEDs). Furthermore, screeners were trained to identify objects from different viewpoints (rotations), when superimposed by other objects and in containers of different complexities.

MEASURING X-RAY IMAGE INTERPRETATION COMPETENCY

The X-Ray Competency Assessment Test (X-Ray CAT) measures how well X-ray screeners can detect different types of prohibited items ([7]). In the test, X-ray images of bags are displayed on a computer screen. The security screeners have to decide whether a bag can be considered as harmless (OK) or not (NOT OK). For this study, a new version of the X-Ray CAT for the field of cargo screening with 240 images was created (C-CAT). Half of the images contained a prohibited item (36 customs related and 24 security related objects). Two versions were designed, one with the original greyscale images, and one where these images were color coded (pseudo color images). For the color coding, an X-ray machine specific algorithm was used which derived the colors from the different levels of grey of the greyscale images.

SCIENTIFIC STUDY: INVESTIGATING THE EFFECTIVENESS OF A COMPUTER-BASED TRAINING

In collaboration with an industry partner, three groups were formed (two training groups with 15 and 16 participants and one control group with nine participants)[2]. Administrative personnel working in customs served as the control group who did not receive any training. Both training groups underwent recurrent training of at least 20 minutes per week with the C-XRT for approximately three months. Detection performance was measured using the C-CAT. Performance was measured before training and again after three months of training to investigate the training effect. The two training groups took different versions of the C-CAT (greyscale X-ray images vs. pseudo color X-ray images). The design of the study is shown in Figure 2.

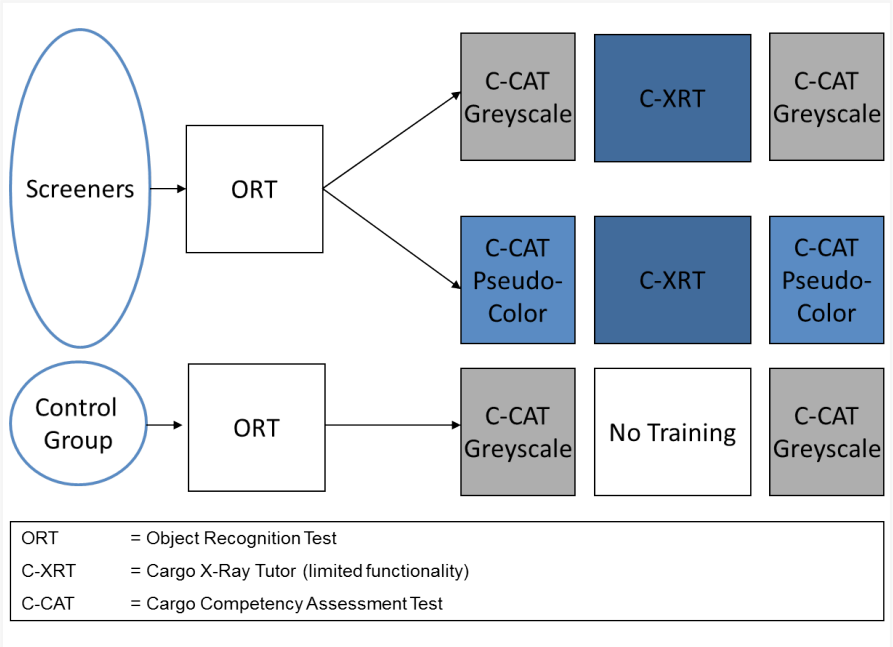

Figure 2: Experimental design of the study

[1] Please note that combined threat images were only used in the study version of the C-XRT. The XRT Cargo as offered by CASRA today uses direct merging during training.

[2] The groups were formed based on the participants' results in the Object Recognition Test (ORT, [10]) which measures visual abilities. It was made sure that all groups showed the same average test performance.

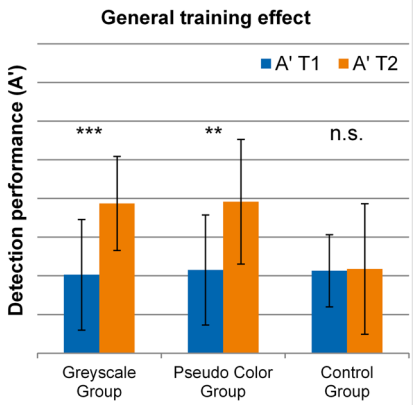

Figure 3: Mean detection performance A' with standard deviations for the greyscale group, pseudo color group and control group at the first (T1) and second (T2) measurement. For security reasons, actual A' scores are not displayed in the figures.

POSITIVE IMPACTS OF TRAINING

Regarding the effect of the weekly training, the results are highly encouraging. **CBT with the C-XRT led to significantly better detection performance scores (A')[3] of the cargo X-ray screeners after three months** (see Fig 3). No increase was observed for the control group which did not receive training. This confirms that improvements of detection performance found in the training groups are indeed due to training. On the level of the single participant, **the more a screener had trained, the better was his or her performance after three months**. Additionally, the time needed by the cargo security screeners to inspect and judge the images as OK or NOT OK decreased through training. Thus, CBT had a positive effect on the efficiency of judgments in the C-CAT. It is highly likely that also in practice, **throughput is positively influenced by training**. Overall, the C-XRT helped to improve X-ray image interpretation competency of the cargo X-ray screeners. Compared to earlier studies on cabin baggage screening (e.g., [3], [4], [8]), the detection performance for cargo was lower. Especially the baseline performance before training was rather low. **This underlines the importance of CBT in cargo X-ray screening**.

Regarding the impact of pseudo color on item detection, no significant effect could be found (see Fig. 3). The group with the C-CAT in pseudo color showed the same performance as the group with the C-CAT in greyscale. The usefulness of pseudo color image enhancement functions is thus unclear.

As described earlier, the threat items contained in the C-CAT were made up of 36 customs and 24 security related items. The security related items contained inert explosives and IEDs, the customs related items were drug items, weapons (guns and knives) and "miscellaneous" (e.g., Chinese medicine, watches etc.) items. **Increases in detection performance after training resulted for every category (see Fig. 4), but were highest for IEDs, which pose the greatest threat to the cargo system. The customs items seemed to be more difficult to recognize**.

INCREASED EFFECTIVENESS AND EFFICIENCY

To conclude, the study demonstrated that detection performance of cargo security screeners could be significantly improved by training. The more the participants trained, the better were their test results after three months. Especially the detection of IEDs and explosives could be significantly improved, although all other categories showed improvements as well. These results are particularly relevant because cargo security has not received the same level of attention as passenger security in recent years. Also, the baseline detection performance before training was rather low for the participating screeners, compared to passenger baggage screening. **These outcomes underline the high importance of training in cargo X-ray screening**.

A further result was that the application of pseudo-color did not lead to better detection performance. Further studies might be needed to show the relevance of image enhancement functions of X-ray machines, such as pseudo color.

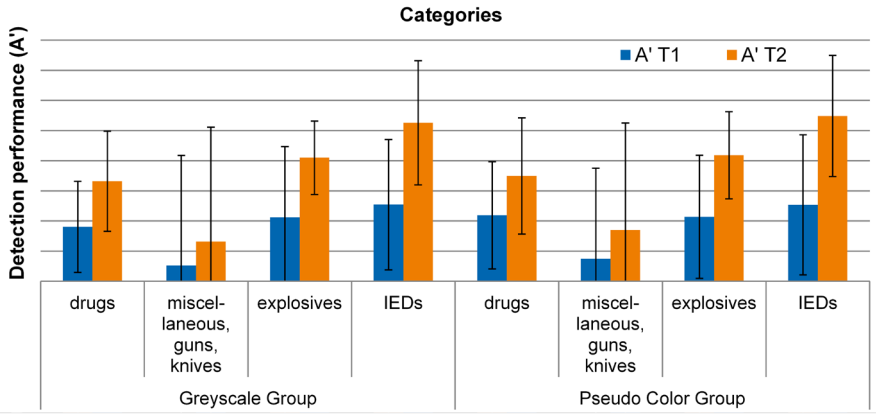

Figure 4: Mean detection performance A' with standard deviations for the greyscale group and pseudo color group at the first (T1) and second (T2) measurement, broken up by category (drugs, miscellaneous, guns, knives, explosives, IEDs).

[3] A' is a measure for detection performance which considers both the hit rate as well as the false alarm rate. A' is commonly used in research and application ([9]).

A journal publication about this study was recently submitted. For any further questions or information about this study please contact Dr. Stefan Michel [stefan.michel@casra.ch].

ACKNOWLEDGEMENTS

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X-RAY SCREENING AT PRISONS: COLLABORATION WITH END-USERS TO CREATE X-RAY IMAGE INTERPRETATION TRAINING

Text: Florian Schmid & Sandrina Ritzmann

You are not allowed to bring your mobile phone, your camera, your MP3-player, a USB stick or any other data storage device (for example the Micro SD card you happen to have in your wallet). And if you are carrying some aspirin, you are not allowed to bring that either. This is the situation encountered by visitors to a prison in Switzerland and in many other countries. The complete list of prohibited items is much longer (and varies from country to country), but the examples already show that security controls at prisons are different from security controls at airports. This article illustrates how CASRA cooperates with experts and end-users to create efficient and effective computer-based training tailored to the area of application (e.g. prison security screening).

Security checks at many prisons worldwide are supported by X-ray screening equipment to detect prohibited items. Good X-ray detection performance is ultimately dependent on targeted training of X-ray image interpretation competencies, as has been described in detail in issue No. 2 of this newsletter. In short, the visual knowledge of threat items and their appearance in X-ray images is essential to detect prohibited items. This knowledge can only be acquired and maintained through regular training. Hence, the question arises whether X-ray screeners working in a prison context need to be supported by a tailored training program for X-ray image interpretation competency to account for the specific prohibited items in their domain. Exactly this question led to a fruitful and ongoing collaboration between the Pöschwies prison, the largest prison in Switzerland with capacity for 426 inmates, and CASRA.

X-RAY SCREENING AT THE PÖSCHWIES PRISON

X-ray screening is performed at several checkpoints at the Pöschwies prison. The personal belongings of prisoners are hand-searched and X-ray screened at entry. If an inmate is transferred to another cell during the sentence, all electronic devices, such as radios, are X-ray screened again. Persons other than the prisoners who enter the premises have to have their bags screened as well. This concerns visitors, workers, lawyers, other professionals, or employees of the prison with a part-time contract (60% or less). Pöschwies sees around 3700 visitors a year. Mail, parcels and deliveries for the different working premises (carpenter's shop, bakery, etc.), but also gift parcels for the inmates, are subjected to further scrutiny before distribution. Small parcels are X-ray screened while larger deliveries are hand-searched, due to the lack of suitable X-ray equipment. X-ray screeners are usually specialized in one of the three screening tasks (inmates/entries, visitors, mail).

There are a number of peculiarities of and challenges to X-ray screening at a prison. Unlike in many other areas where X-ray screening is part of the security process, time pressure is not an issue at Pöschwies. If anything on the X-ray image is unclear, a hand search is performed. Another option is to call a second person for an additional opinion or to double-check the special clearance for certain objects. In certain cases, single items are screened separately again, for example the contents of a gift parcel. Regarding the prohibited items, the detection of weapons and items usable as weapons is highly important to prevent hostage-taking and other serious incidents. Unusually-shaped weapons like pen guns, but also drugs hidden in organic material (e.g. in manipulated food tins), technological innovations like ball-point pens with recording function, or ever-smaller data storage devices to smuggle information present a considerable challenge to the X-ray screeners.

For prisons, training of X-ray image interpretation competency in Switzerland is in the responsibility of the prisons

themselves. At Pöschwies, new X-ray screeners are trained in a mentoring system. Experienced screeners train new employees on the operation of the X-ray machine and do one-on-one training sessions with them using X-Ray Tutor for Prison Security Screening (XRT Prison). Subsequently, on-the-job training follows, whereas the mentor gradually transfers the responsibility to the new screener.

COLLABORATION TO TAILOR TRAINING FOR INCREASING X-RAY IMAGE INTERPRETATION COMPETENCY

The cooperation and collaboration with experts and end-users is an important objective of CASRA to guarantee the practical relevance of our work and products. Already in 2007, experts from Pöschwies prison, together with researchers from CASRA, determined the peculiarities of X-ray screening in a prison to subsequently design a computer-based training to increase X-ray image interpretation competency in this area. First, the prohibited items to be included in the training image library were identified and recorded from different viewpoints. Second, the ratio of different types of prohibited items was determined to mirror their relevance in the prison context. Third, the experts from the Pöschwies prison agreed to provide CASRA with images of clear bags typical for their day-to-day work. These efforts resulted in the first version of the XRT Prison. A peculiarity of this version was that it contained a considerable amount of X-ray images of vacuum cleaners because at the time, they were repaired at Pöschwies as an employment scheme for the inmates. Today, the library of clear bags is up-to-date and consists of a more general set of images suitable for all prisons. These images are still regularly provided by the Pöschwies prison. The newest version of XRT Prison is described in more detail in the infobox. It is in use at over one hundred prisons worldwide, including seven in Switzerland.

To further advance the quality of the image libraries of XRT Prison, a survey was conducted in the first half of 2013 at a number of Swiss prisons. It was asked which specific items from the categories guns, knives, and others (with a special focus on electronic items which are important in the prison context) should be in- or excluded in the training software. Furthermore, the ideal ratio for training of the categories guns, knives, explosives, and others was requested. The survey revealed that, in addition to the existing complete objects, more single parts of objects such as small components of mobile phones or knives should be included as prohibited in the training software because they can be smuggled separately to finally reconstruct the complete item. Furthermore, medication, pills and tablets and also more types of illegal drugs were asked for. These suggestions have been taken into account in the revision of the library of prohibited items. Other suggestions such as the inclusion of letters or notes (uncensored post within parcels) could not be considered due to the delicate appearance of these objects in X-ray images. Regarding the ratio of the different categories of prohibited items, a reduction of explosives in favor of more items from the category others was decided because explosives are less relevant than, for example, in the aviation sector.

To conclude, XRT Prison is an example where the collaboration with practitioners and field experts has led to fruitful results and to expedient adaptations of training.

For further information on the XRT Prison, please contact Florian Schmid [florian.schmid@casra.ch].

INFOBOX: X-RAY TUTOR FOR PRISON SECURITY SCREENING

XRT Prison is the prison-specific edition of XRT3. The image libraries of XRT Prison are designed in a way that prison staff can be optimally trained to detect objects that are relevant in the daily screening in prisons and correctional facilities. These are items from the categories guns, knives, explosives, and others. The latter specifically contains drugs and electronic items. Electronic items that are prohibited in prisons are for example mobile phones, digital cameras and data storage devices. Unlike in airport-specific versions of the XRT, unconventional guns and knives as well as prison-specific objects have a higher priority than explosives in the XRT Prison. To ensure high relevance, the threat library is updated annually with the help of weapon and drug departments of police authorities. The bagset used in XRT Prison reflects the everyday screening task to a large extent since the images are taken from the storage modules of prison X-ray units and therefore reflect all application areas such as the access control, the screening of personal belongings of prisoners as well as gifts from visitors. In addition to that, by the end of 2013 an extended version of XRT Prison also containing bags and threat items from prison mail screening area is going to be available.

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