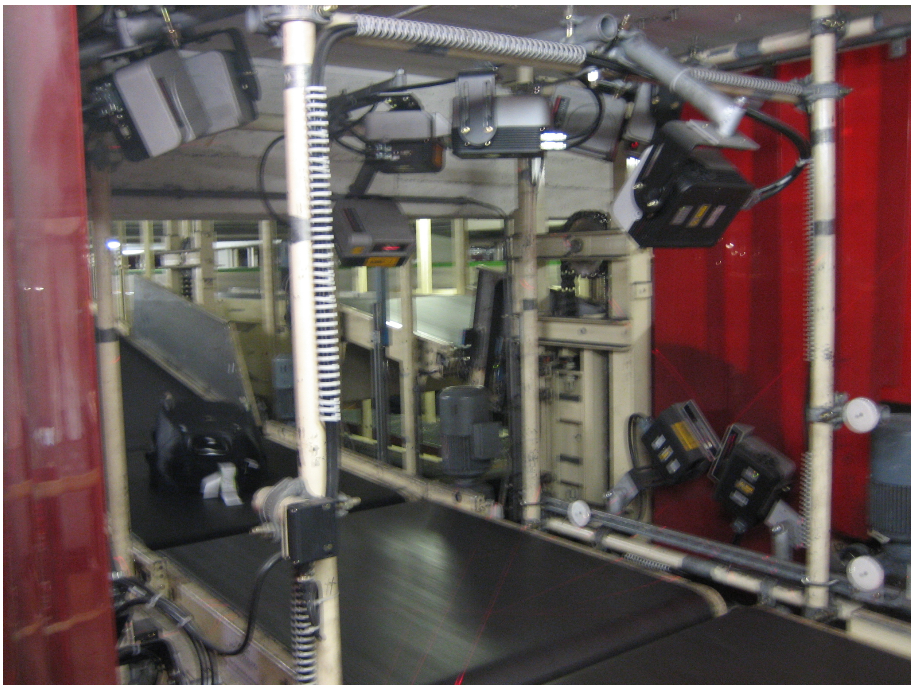
Image processing applications at Vienna Airport with basis in Baggage handling



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Abstract

This paper gives a visit report from the baggage handling halls at Vienna International Airport together with texts about image processing applications at airports. The paper is the final written document for the excursion group in the course “Applications of Image Processing” at Vienna University of Technology. The foci in the technical texts are on illumination, configuration (environment), software (algorithms) and hardware. The areas that are covered are: scanners at different wavelengths, fingerprint-, face-, and iris recognition, future image processing applications at airports and finally some applications from a car factory. Pictures from the excursion are given in the end of this paper.

Contents

1 Introduction

The course Applications of Image Processing 183.155 at Vienna University of Technology consists of both lectures and exercises. This paper is the written report for the excursion exercise. The excursion was made the 30th October 2008 to Vienna International Airport. The original purpose of this text was that all members in the excursion group should explain one image processing application that is present in the baggage handling area at the airport. This narrow aim has later been widen to image processing applications at the whole airport, since too few methods in this area are used in baggage handling today.

The structure of this report is very straight on. The different image processing methods are divided into sections. Such a splitting makes it easy to see who have done what. After an introductory survey of the excursion day, "The baggage handling system at Vienna airport", the image processing applications in the baggage handling will be discussed, "Auto ID Data Capture and Barcode Scanners" and "X-Ray scanning". The following sections present different image processing applications that can be used in airport security, "Fingerprint recognition", "Face recognition", "Iris recognition and "Whole body image". This paper ends with two sections that deal with image processing in airport future, "The Future of Image Processing on Airports" and in a car factory, "Image processing at Volkswagen Bratislava".

2 The baggage handling system at Vienna airport

The excursion started with S-bahn (commuter train) from Vienna. At the airport we were welcomed by Manfred Pölz . He worked as manager for the computer systems that operate and control the baggage functions and as well as our guide for the day. Before moving up to manager, he was loader at the floor for 20 years. In other words Manfred Pölz knows what he talks about.

The first thing to do was to receive the visitor badge and place it visible to your clothes. The next step in order to enter the baggage handling hall was a normal airport security test. After the circumstantial process of removing and restoring metal objects we were finally ready to move into the control room for the old baggage hall. It looked just like every other control rooms, a lot of screens and displays that describe the current state in the flow. Simple and effective solutions with cameras covering the flow and operators that can switch to the different camera views when they get indications from a computer system that something is wrong somewhere in the flow.

Manfred Pölz described the baggage flow from check-in counter to airplane loading with aids of camera views displayed on the screens. The same information that is attached to bags at counters in form of tags is also sent to a server belonging to the responsible airline. The checked-in bags are placed on conveyor belts, heading for the baggage handling hall. An early station in the handling hall X-ray all baggages. The picture for each bag is semi-automated examined. A bag can be graded from one (nothing abnormal) to five (blow it up). Manfred Pölz had never experienced the latter gradation under his more than 20 years at the airport. The tag-number of the past baggage is thereafter scanned in a following station, see figure A.1 and A.2 on page II. The previous mentioned servers are asked for the destination. This information is entered to a computer system that manage a conveyor belt consisting of tiltable plates, see figure A.6 on page IV. A scanned bag is placed on one of these plates. Chutes from this conveyor belt ends up in loading spaces for each airplane. A plate with a bag that should be on an airplane named A will be tilted when it passes chute A. The loading space also works as a buffer. Operators walk around between the chutes and load carriages and containers that later are transported to the airplanes, see figure A.3 and A.4 on page III.

The trip continued to the old baggage handling hall after the oral presentation. The next stop was the new baggage handling hall. Apart from newer machines and conveyors, the approach was a bit different. In order to have a fast changeable system, due to airplane delays, the idea with tiltable plates was removed and replaced with operators, see figure A.5 on page IV. To take a step back in the eyes of an automation engineer. Manfred Pölz also claimed that this approach was better suited to handle transfer luggage. He stated that a mix of the two systems is very common in recently built baggage handling halls. Luggage for airplanes with take off more than a certain time, usually two hours, from the present is stored since the number of loading spaces is limited. Before it was time to close the cycle and hand back the visitor badge we did take a quick look at the control room of the new baggage handling hall. Very similar to the other one in purpose and structure, only differences in age of equipment.

The S-bahn trip back to Vienna gave time for reflection. As engineer you are always looking for problems to solve. The problems that Manfred Pölz gave for baggage handling could not be solved with image processing applications. This can be comprehended when Manfred Pölz gave his view of the introductory problems at Heathrow terminal five. According to Manfred Pölz it was many small problems that escalated to the airplane cancellations the first days after opening. Some of the problems in the baggage area were that operators for the loading spaces either were trapped in car cues at the new highway or unable to enter the buildings due to nonfunctional new key cards. The few operators at the floor struggled with a new nonworking automated carriage refilling system. This made the chutes packed in almost no time. Manfred Pölz finished this description with saying that the baggage handling system for the new Skylink terminal at Vienna airport is from the same firm as the one in London.

3 Auto ID Data Capture and Barcode Scanners

3.1 Auto ID Data Capture

Automatic identification and data capturing technologies include identifying the objects automatically, getting information about them, and saving that information in order to use when it is needed.

"AIDC technologies include barcodes, RFID, OCR, magnetic stripes, smart cards and biometrics." [1]

3.2 Barcodes

"A bar code (also barcode) is an optical machine readable representation of data." [2].

Earlier, bar codes represented data with parallel lines, but later on they are designed as patterns of squares, dots, hexagons and other geometric patterns called 2D matrix codes or symbologies. Although there are no bars, 2D systems are often referred to as barcodes.

The first use of barcodes was in groceries (household and foods stores), nowadays we see barcode scanners in almost every shop. Their use is widespread and referred to as Auto ID Data Capture. Newer systems, like RFID, are attempting to take their parts in the market.

After their invention, barcodes have slowly become an essential part of modern civilization. Their use is widespread: grocery stores, department stores, document management and the tracking of item movement including rental cars or airline luggage.

3.3 Scanners (barcode readers)

Barcode scanners can be classified into categories in respect to their connection to the computer or database. The older type (RS-232) requires programming to transfer the input data to the computer system. The USB barcode scanner is a more modern and more easily installed device and has the advantage that it does not need any code or program for transferring input data to the computer system; when you scan the barcode its data is sent to the computer as if it had been typed on the keyboard.

3.4 Bag tags

"Bag tags, also known as baggage tags, baggage checks or luggage tickets, have traditionally been used by bus, train and airline companies to route passenger luggage" [3].

Currently bag tags include a bar code, thus allowing the automated sorting of the bags.

"Automated sorting of baggage using laser scanner arrays to read bar-coded bag tags is standard at major airports." [3]

In airports these tags are printed in check-in to be attached to each of the passengers' luggage before they are sent to a conveyer and they have all the flight information on it, including the destination and any stopover cities, as well as a bar code that has a ten-digit number, which is unique for each passenger. All of the computers in the baggage-handling system can use this unique number to get the specific travel route.

After check-in the first stop of a bag is an automated bar-code scanner. Here there is an array of bar code scanners arranged 360 degrees around the conveyer, including below. 360 Degrees scanners are able to scan the bar codes about 90 percent of the luggage that pass by. The rest of the bags are routed to another conveyor to be manually scanned. From the tracking perspective, once the 10-digit bar code number is read by luggage handling system, it is known where the bag is at all times.

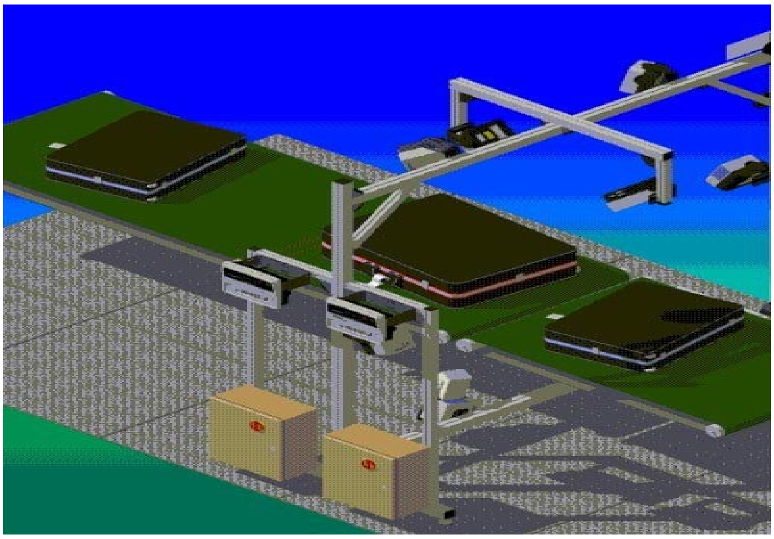


Figure 3.1: Scanners are able to read the barcodes anywhere on each baggage. [4]

“Bar codes can not be automatically scanned without direct sight and undamaged print.” [3]

Based on data from the Assn. of European Airlines, 16.6 of every 1000 items of baggage failed to arrive at the final destination together with the passenger throughout the Air France-KLM networks in the first nine months of 2006. Air France Luggage, Ramp and Transfer Domain Manager Benoit Thibaudon says current barcode technology is one of the culprits for mishandled baggage. “You can never achieve a 100% read rate of a barcode, not even with the new 360-degree readers,” he says “if the bag tag is new, just printed for local departure, the read rate might be more than 95%. However, for baggage in transfer it is more around 80%.” [5]

Because of reading problems with poorly printed or damaged bar codes, some airlines have started using and testing radio-frequency identification (RFID) chips integrated in the tags, and by the time the results are encouraging. Airports in North America, Asia and Europe are using RFID bag tracking, with mostly positive results. Furthermore in lots of countries new passports are all RFID chips integrated.

In the US, McCarran International Airport and Hong Kong International Airport have installed an RFID system throughout the airport, furthermore the International Air Transport Association (IATA) is trying to standardize RFID bag tags. [3]

4 X-Ray scanning: Introduction to the physical background and applications for security application

Nowadays, the X-Ray scanning is widely used as well for Medical applications, for non destructive imaging applications or also for the security issues (for example in the airports). First, the general physical principle of the x-ray will be explained, then the different techniques will be presented and a particular attention will be paid on the application related to the security issues.

4.1 Physical principle

4.1.1 Description of the x-ray

There are two complementary points of view to consider on the X-Ray: as electromagnetic waves or as elementary particles (photons). We will not go deeper into these considerations, which are developed by the relativistic quantum theory but for our purpose the knowledge of this duality is necessary to have a basic understanding of the x-ray phenomena. For some applications of imaging we will consider only the x-ray as a set of particles, which interact with atoms and for some other applications we have to consider them as electromagnetic waves (especially for understanding the diffraction). First, we can consider in some point of view the x-ray as an electromagnetic wave, with a frequency going from: 30×10^{15} Hz to 30×10^{18} Hz and with a wave-length in the vacuum between in the range of 10^{-8} to 10^{-12} m.

In order to get a clearer vision of these values, it is possible to refer to figure 4.1.

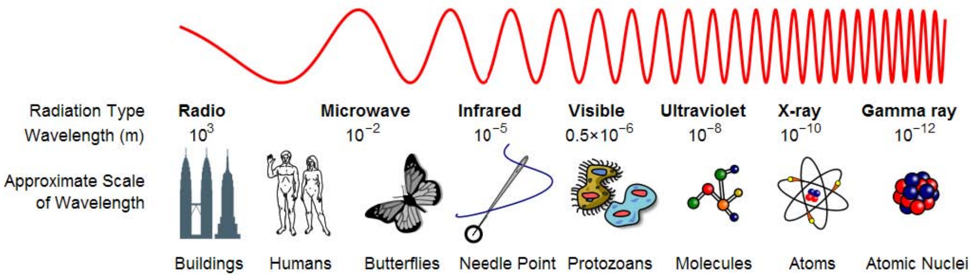


Figure 4.1: A diagram of the EM spectrum. [6]

In the case of the X-ray, they could be considered as a flow of particles called photons and because of the high frequency of the electromagnetic waves, we can associate to them a high energy (from the order of the e-V to several Me-V). It is important to notice that the photons are neutral at the electrostatic point of view and also their masse is considered as equal to zero.

4.1.2 Interaction of the X-ray waves with the matter

If we consider the imaging applications, the interesting property of the x-ray is their interaction with the matter. The interaction of the X-ray with atoms or molecules is highly depends on the atomic mass of the interacting element. Simply, it is possible to consider at first approximation that the absorption of the x-ray by the weak atoms (carbon, hydrogen) is lower than the absorption by the heavy atoms (for instance: mercury). We will see that this property is especially interesting because, by this way we can distinguish between the different elements. But there are also some other interesting properties as: the absorption of the x-ray through the air, the diffraction of the x-ray on a crystal network, the ionization of the material with the interaction with x-ray but unfortunately because of the space limitation these properties could not be developed here.

4.2 General principle of the x-ray imaging and some scanning methods

We will focus on the techniques, which could be used for imaging objects in respect to our airport application.

4.2.1 General principle

All of the x-ray imaging process are at least composed of:

- a x-ray generator
- the object to image (which will receive the beam of photons)
- a receptor (which will receive the resulting x-ray beam)

Different kind of x-ray generators and receptors exist. Some of them are more commonly used in the industry (for example the tungsten cathodes) and some of them are used more for fundamental research applications (cyclotron). This part of the work will not be detailed because it is out of our original purpose.

4.2.2 The oldest technique is the projection radiography

This technique has been discovered at the end of the 19th century. The principle is simple: a beam of x-rays is directed to the observed object and thanks to an electronic detector or a sensitive surface, it is possible to get a resulting picture with different contrasts.

As explained before, this contrast will depend on the absorption of the photon through the observed object. So the more the object will absorb the photons, more the resulting picture on the receptor will be dark.

This method has a simple principle but also some limitations:

- it is possible that the observed object could not contain elements which enough different absorption difference, so the resulting picture will not have important contrast difference.
- the picture we have is a projection on a 2 dimension plan of the penetration of wave through one or different media. So it will generate first a geometric distortion of the objects and also it is possible that a very absorbing media can absorb a lot of photons what will avoid distinguishing the other media in the ray direction.
- if these methods is directly used to image organisms, the x-ray could generate ionization of the molecules in the organisms and then cancers.

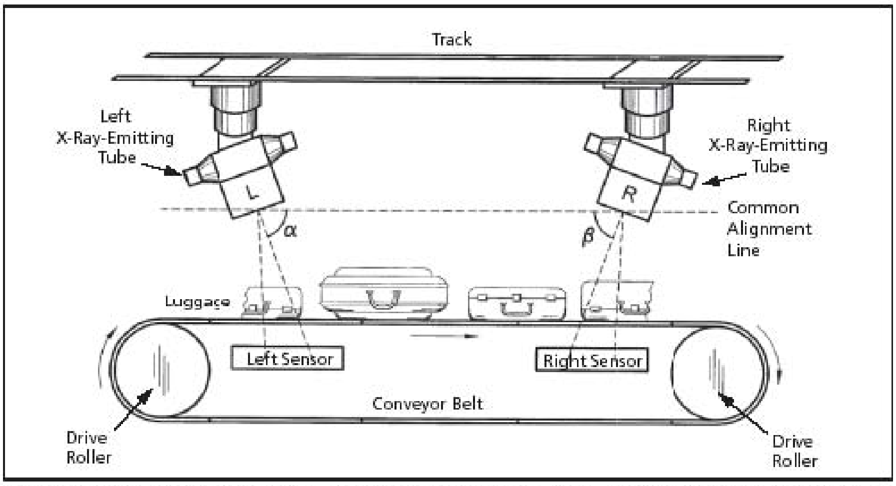
4.2.3 The x-ray tomography

The basic idea is to combine, the projection radiography with some data processing in order to get a picture in 3 dimensions. For instance, the object could be placed inside of a cylinder and then a x-ray source is rotating automatically around the object in order to get several view. Then a volume reconstruction of the object could be computed and several visions of the object into different slices could be done. Compared to the previous methods, this method has the advantage to be used for suspicious objects, which could use some devices in order to avoid detection with the simple projection radiography.

Furthermore, this technique have the advantage of allowing more accurate determination of the absorption of elements (because it is possible to reduce the effect of the absorption due to the high absorption elements). But, this method does not fix the problem of the radiations on organisms and also this method is still a time-consuming and calculation method (it explains why this methods is especially used for suspicious bags).

4.2.4 Stereoscopic x-ray screening

This method is also an improvement of the projection radiography, which has been developed recently by the NASA. One of the biggest difficulties of the human operator in the airport is to interpret picture in two dimensions (projection on a plan). For fixing this issue, it has been proposed to use two different x-ray camera-receptor devices and then with a special image processing application, the human operator can have a picture in form of a stereoscopic image.



Images From the Left- and Right-Eye X-Ray Sensors are captured at different locations and stored along with conveyor position data allowing the appropriate left- and right-eye images to be viewed by the human operator on a commercially available stereo display screen.

Figure 4.2: Illustration of the stereoscopic x-ray scanning. [7]

4.2.5 Coherent scattering

This technique exploits the property about the similar order of magnitude of the x-ray wave length and of atomic structure in order to get specific diffraction patterns. This method is not already exploited in industrial security applications but it is an active field of researches.

4.3 Conclusion

We got a brief overview of different baggage inspection methods. To summarize, the x-ray method has the advantage to be fast, non invasive (except for organisms). Some active research fields concern the optimization of the spatial imaging and the detection of specific substances by x-ray diffraction.

5 Fingerprint recognition

5.1 Concept

Since its first use in 1892, Fingerprints recognition has been one of the most well-known methods employed by police and other institutions around the world in matters of security. However, it is thanks to the application of image processing that this system has been developed up to an outstanding level, reaching such a precision that makes Fingerprints recognition one of the essential security systems in the current world.

Fingerprints recognition turns out to be based upon a process that involves two different phases, Minutiae Extraction and Minutiae Comparison [8]. This procedure still being the same as its origin, nevertheless to say, it has also been dramatically enhanced due to computer developments. Different sorts of Hardware and Software have appeared so as to make this system more and more accurate, despite the fact that a physical non-computerized tool will be always needed: the fingerprint itself [9].

5.2 Hardware

A wide range of different sensors to obtain the digital fingerprint image can be found nowadays. Those sensors are divided in up to four different types: Optical Sensors, Capacitance Sensors, Ultrasonic Sensors and, finally, Thermic Sensors [10].

Currently, Optical Sensors are the most used type, and because of it, they are constantly being improved and enhanced. Their principle is quite simple, yet what they are designed to is merely to obtain a digital image of the fingerprint using the same process as a scanner.

Capacitance sensors, however, are divided into two groups: passive capacitance and active capacitance. Despite the fact that both of them work on the same principles - they work through capacity and impedancy of electricity, yet there is significantly much less capacitance in air-valleys than in the different ridges - passive models use the voltage the own body, while active ones apply a small voltage charge so as to get more accurate results [11]. For Ultrasonic Sensors, it is to say that they work with high frequency sounds and measuring the different changes in these sounds reflects. Finally, Thermic Sensors work under the different temperatures between valleys and ridges, and because of that, require a long-timed exposition, so as to be able to detect those thermic differences [12].

5.3 Process, Software, Algorithms, Formats

Every human fingerprint is classified into six different patterns, Arch, Tented Arch, Left Loop, Right Loop, Twin Loop and Whorl [13, 14]. Inside these different fingerprints, it can be distinguished different "Minutiae" or "Galton Points", which take their name after Sir Francis Galton, pioneer in Fingerprints recognition [15]. For the process it is always needed a pair of fingerprint, one previously stored in the Data Base, and another which refers to the input.

The type of fingerprint is obtained thanks to the deltas and the cores, which are respectively the point where three ridges converge, and the highest point of the inner ridge of a loop.

The location and orientation of those points are determined through the Rao Method, which first work out the gradients Gx(i,j) and Gy(i,j), and then, the main direction is obtained in 16x16 blocks.

The next step in the process is to extract the different Minutiae, for that, every fingerprint is scanned into an image of 500 dpi, in order to create a Fingerprint Map, in which to look for the Minutiae [16]. In order to find them, every Fingerprint Map is divided into 32x32 pixels blocks, in which every Minutiae found is assigned to a pair of coordinates, x and y, and an angle, θ, which refer to their location. In order to prevent different errors due to physical inaccuracies, those Minutiae are located within a range of +/- 4 unities [17].

After the Minutiae extraction, comes the Minutiae Comparison, in which every Minutiae found before is compared, so as to prove that the pair of fingerprints that are being studied belongs to the same person. For that, a previous aligning phase is required, since different inaccuracies can still be present. After that, every minutia is converted into polygons based upon the polar coordinates system, and then, a series of matching algorithms are applied. This matching process is not actually applied to the Minutia itself, but to the Ridge from the Fingerprint in which the Minutia is located. Thanks to this matching process, it is possible to determine whether the two different fingerprints really belong to the same person or not.

Apart from that, the image has to be processed through the Hough Transformation, which optimizes the search for the best match [18].

5.4 Formats

A wide range of formats are used to store the fingers into the Data Bases, the majority of them under the standards ANSI/ICTS, ISO/IEC and ISO/FCD. Apart from that, there are formats such as Wavelet Scalar Quantization, WSQ, used by the FBI in the United States, and the worldwide spread JPEG (Join Photographic Expert Group) [19].

5.5 Problems and Noise

Due to the physical nature of the fingerprint, it can happen that noise leads the recognition to a false result. To avoid that, several methods have appeared, each one regarding a different problem.

The first and primary problem that can be found is the ink process used in the past to obtain the fingerprints pictures. To avoid that, a new generation of inkless scanners appeared during the 90s, digitalizing every fingerprint directly from the fingertip and not through ink ways.

It can also happen, that, after having recognized the fingerprint, and having correctly extracted the minutiae, those can be false because of the nature of the finger - ridges and minutiae can be broken and have spikes. Then, a smoothing method is required.

Those smoothing methods are divided into Heuristic ones, Stepwise Refinement based on Structural Information and Readjustment of the information added to the Minutiae.

The first one involves two different procedures: when a branch of the broken ridge is perpendicular to the ridge's direction and its length is shorter than a valley, it has to be removed; and when a split is so small that it cannot be crossed by other ridges, the extremes have to be joined.

The second one is based on other two procedures: when a group of minutiae are so closed that form a cluster, every minutia is removed, except the one which is located nearest to the center; and, when tow minutiae are placed extremely closed, so as it is impossible for a ridge to be between them, both minutiae have to be removed [20].

Finally, the third one works on the position, orientation and the ridge associated to every minutia.

6 Face recognition

Face recognition systems consist of extract patterns from pictures so that the identity of people can be recognized by an automatic process. The most usual application is to analyze images or pictures to identify people on the picture. To achieve this, we need a database with the parameters or patterns of the people we want to recognize in the image.

It is typically used in security systems and can be compared to other biometrics such as speech, fingerprint or eye iris recognition systems. The main difference is that with face recognition the cooperation of the people is not required.

Some facial recognition algorithms identify faces by extracting landmarks, or features, from an image of the subject's face. For example, an algorithm may analyze the relative position, size, and/or shape of the eyes, nose, cheekbones, and jaw. Other algorithms normalize a gallery of face images and then compress the face data, only saving the data in the image that is useful for face detection. A probe image is then compared with the face data. [21]

There are two well defined techniques in the problem of face recognition: The geometric one, based on the face characteristics and the photometric, based on the visuals.

As the researching was being developed, many different algorithms were made up, three of them have been the most studied in the face recognition literature.

- Principal Components Analysis (PCA). It was developed in 1988. The gallery of images in the database should be of the same size. It means, that the images must be normalized so that all the images have the same dimensions and put in line the eyes and mouth of the subjects. The PCA approximation is then used to reduce the dimension of data by compressing them. This method takes away useless information and decomposes the facial structure into orthogonal components known as eigenfaces. Each facial image can be represented as the averaged sum of the eigenfaces, which are stored as a set. Then, a probe image is compared to a gallery of images measuring the distance between its pattern vectors. The PCA approximation requires the whole front face to be presented each time. Otherwise the image would give a low efficient result. The main advantage of this technique is that it can reduce the needed data to identify a person to 1/1000 from the presented data.

- Linear Discriminant Analysis (LDA) is a statistical approximation to classify samples of known classes based on trained examples (i.e. between users) and minimize the variance of each class. When it is about high dimension facial data, this technique fights with the problem of small size samples, which appears when there are a short number of training examples compared to the number of possible candidates.

- Elastic Bunch Graph Matching (EBGM) takes into account that real facial images have many non linear properties that are not analyzed in the previous methods, such as differencing indoor and outdoor illumination, the face position (frontal or leaning), the expression: smiling, frowning, laughing, etc. [22]

Besides all this algorithms, we must not forget, that the algorithms work with a two-dimensional image of a three-dimensional face. That is why a new technology is being developed working with 3D sensors to capture information about the shape of a face. This gathered patterns are then used to identify distinctive features on the surface of a face, such as the contour of the eye, sockets, nose, and chin. The most important advantage of this technique is that it is not affected by changes on lighting and it also is able to identify a face from a range of viewing angles, including a profile view.

Another way to improve the face recognition accuracy is to include a skin texture analysis, which is another emerging trend that uses the visual details of the skin, as captured in standard digital or scanned images. It turns the unique lines, patterns and spots apparent in a person's skin into a mathematical space. Tests have shown that with the addition of skin texture analysis performance in recognizing faces can increase in a 20-25%. [23]

Some concrete face recognition applications have been:

- At Super Bowl XXXV in January 2001, police in Tampa Bay, Florida, used Indentix's facial recognition software, FaceIt, to search for potential criminals and terrorists in attendance at the event. (it found 19 people with pending arrest warrants)
- In the 2000 presidential election, the Mexican government employed facial recognition software to prevent voter fraud. Some individuals had been registering to vote under several different names, in an attempt to place multiple votes. By comparing new facial images to those already in the voter database, authorities were able to reduce duplicate registrations. Similar technologies are being used in the United States to prevent people from obtaining fake identification cards and driver's licenses.

There are also a number of potential uses for facial recognition that are currently being developed. For example, the technology could be used as a security measure at ATM's; instead of using a bank card or personal identification number, the ATM would capture an image of your face, and compare it to your photo in the bank database to confirm your identity. This same concept could also be applied to computers; by using a webcam to capture a digital image of yourself, your face could replace your password as a means to log-in. [24]

What we can expect for a near future is that, when face recognition algorithms are good enough, people can be absolutely localized. We all know there are cameras all around the street and almost everywhere. If there is a database with an image to compare with, all the process is done. All the people in some place can be identified. If there is no access to this kind of database (i.e. the police or government ID databank), there is always somebody to access social networks such as Facebook or Myspace, where lots of images are tagged to people and, what is more, to personal information.

7 Iris recognition

Iris Recognition is the process of identifying a person by analyzing the iris. The way of identifying a person by using the iris recognition method is a well known research field when thinking of airport security.

7.1 The Iris

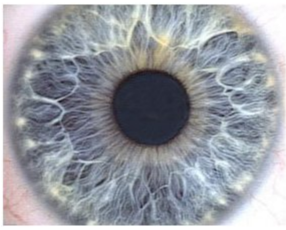


Figure 7.1: Iris [25]

The iris, as in picture1, is a muscle regulating the size of the pupil of an eye. It is controlling how much light enters the eye. The iris is colored and is placed around the eye's pupil. The color of the eye's pupil is varying and depends on the genes [26].

The iris grows in the prenatal phase and the forming and folding of the iris develops. Before a child is born, the degeneration occurs resulting in the pupil opening and the random pattern of the iris [27].

7.2 Iris Recognition

Figure 7.2: Iris recognition at US airports

TThe iris recognition, as seen in the above picture, exists of two phases: a phase preparing the iris recognition and a phase executing the iris recognition. In the first phase the iris is located. It means that landmark features are detected. [28] The important step in this phase of iris recognition is the step concerned with locating the iris features. When getting a well taken photo without any noise, the image processing can deliver highly reliable results. The noise could be eyelashes, reflections, pupils or eyelids.

After computing the landmark features and the shape of the iris is ready for imaging. Within the next phase the image is taken and the features are isolated and extracted [26]. When taking the image, a high quality digital camera has to be taken to get high quality data.

7.3 The algorithm

The algorithm of the iris recognition has several steps which are described here. Operating on that picture the algorithm tries to extract the features of the eye [26].

At first the algorithm has to identify the outer boundaries of the iris and the pupil in an image of an eye. The pixels of the image displaying the iris are transformed into a bit pattern which is now ready for the computation. The computing includes a statistical analysis being necessary to compare two pictures.

For transformation a Gabor wavelet transform is used [28]. Next a spatial frequency is extracted containing a good best-signal-to-noise ratio. The result of that step is information about the iris image including local amplitude and phase information. All amplitude information is discarded and the result is a 2048 bit representation of the image. With discarding the amplitude information the image is reliable concerning different illumination models.

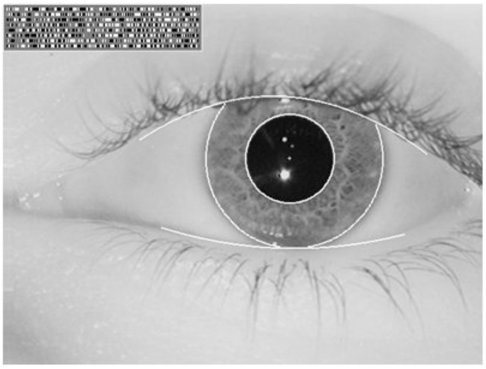


Figure 7.3: Iris and Iris Code [29]

The recognition of the iris, displayed in the above picture, is saved as a template and authentication or verification is done by taking an image of the iris calculating the representation bits and comparing the bits to the saved template. If the Hamming distance of the representation and the template are not above a certain level, an identification can be done correctly.

7.4 Advantages of iris recognition

- The iris is an internal organ being protected against external influences [28].
- The iris is flat and the geometric form is controlled by muscles [28].
- The iris has a fine texture like finger prints [28].

7.5 Disadvantages of iris recognition

- The fingerprint recognition is more usual field of usage [28].
- Iris recognition is hard to make for a larger distance than a few meters [28].
- With bad quality images the algorithm is performing worse [28].

The problem of iris recognition is the live recognition. There the algorithm has to output reliable data for comparison and identification. Some security aspects have to be considered:

- Testing the pupillary reflex and recording different pupil diameters
- Testing the eye for retroreflection (red eye effect)
- 3D imaging for verifying the position and shape

7.6 Application at the Airport

One field of usage for iris recognition is at the airport scanning the passengers' eyes when arriving. One of these systems is the IRIS system of the United Kingdom [30]. There the passenger can register at the system and the registered passengers are allowed to enter the borders through automated barriers at certain airports.

The system takes advantage of the fact that the pattern of the iris of each person is unique and thus it is possible to identify a person looking into a special camera. The IRIS system uses a photograph of the iris pattern and converts it into a digital code and compares it to the stored value in the database like the above described algorithm [28].

It takes 10 minutes for registering to the IRIS system [30] and then a passenger can pass the English border within 20 seconds every flight. The airports where the system is installed are:

- all five Heathrow terminals
- Manchester terminals 1 and 2
- Birmingham terminal 1
- Gatwick North and South terminal

7.7 Different ways of using recognition at airports

The different ways of using iris recognition at airports are:

Table 1: Usage of iris recognition at airport [31]

Purpose	Installed at location
Iris as passport	Amsterdam, Frankfurt
Processing and checking for departing passengers	Boston, Los Angeles, Minneapolis, Houston
Airline Crew facility access	Charlotte Douglas Airport
Employee access to restricted areas	New York, Albany, Frankfurt, Amsterdam, Canadian Airports
Watch List Screening	Arab Emirates, 7 airports

7.8 Conclusion

The iris recognition is used at airports nowadays. It is used for different security problems. The most useful for the passengers is the passing of the border. Different setups at different airports are available around the world. One is the IRIS system at the UK. Generally the users have to register at the system to have their iris pattern saved. After that the passengers are able to pass the border anytime. The algorithm used within these systems is developed by Daugman [32]. The trend at the airport is an expansion of iris recognition systems at different security levels because of fast recognition and high reliability. The iris recognition is nearly as precise as the finger print.

8 Whole body image

This is a current topic at the moment due to the last month's discussion within the European Commission and Parliament about using whole body scanners at European airports. Although people are scanned at some US airports and a system has already been tested in Amsterdam, Zurich and London there still does not exist a general regulation about adding this technology to the security checks at European airports [33]. One of the reasons for that might be the different aspects to be concerned, as there is the technical and security aspect combined with data security, privacy and health thoughts that play an important role too.

Mainly this topic is about scanning persons at airports for detection of weapons, explosive goods and other threat items, concealed under layers of clothing, without physical contact. Another advantage to the now used detectors is the possibility of detecting also non metallic weapons like ceramic knifes and plastic explosives. The problematic, highly discussed part is the fact, that all used technologies produce pictures which show all bodydetails of the passenger.

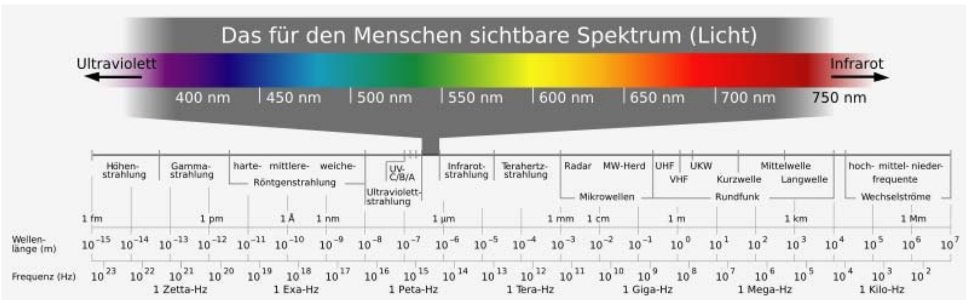


Figure 8.1: Electromagnetic spectrum, courtesy of ComputerBase Medien GbR

Currently there exist three different technologies which are already used regularly or tested on an optional basis on airports. Figure 8.1 shows the different parts of the electromagnetic spectrum which are important for the applications.

8.1 Backscatter

This was the first technology used in the field of airport security for detection of dangerous goods, besides metal detectors and pat downs by security personal. One of the enterprises which were the pioneers in this field was Rapiscan Systems [34]. Their backscatter Scanner was used at London Heathrow already in 2006. Tests have taken place even earlier, since around 2002. The following year some US airports started testing this technology and today it is standard on all bigger American airports, like for example Los Angeles and JFK in New York.

When X-Rays are used for example in the medical field a burst of high energy photons is send at a person. The energy penetrates the person and the amount which is not absorbed or scattered is captured on X-Ray films placed on the other side of the person. Organic material with low density tends to scatter X-Ray particles, which is the reason why for example soft tissue is not visualized well with this scans.

Backscatter scanners are based on exactly this effect and use detectors for the scattered energy instead. The person's surface is scanned with a narrow low energy X-Ray beam at a high speed. The radiation reflected back from the body and all objects on it is detected and converted to a computer image [35]. Figure 8.2 shows an image of a woman scanned with backscatter technology.

The dose of radiation a person is exposed to with one scan is due to the Transportation Security Administration (TSA), USA [36]not higher than with flying two minutes at cruising altitude.

Figure 8.2: Backscatter image of a woman, courtesy of TSA

8.2 Millimeter Radiation

This term refers to Microwaves which have wavelengths between 1mm and 10mm. They are used for example as radar by the military and for the adaptive cruise control, which controls the distance to the vehicle in front, by the automobile industry.

The technology using Millimeter waves is the new standard at US airports where the TSA [36] uses a system of L3 communications called ProVision [37]. Figure 8.3 shows an image of the L3 Millimeter Scanner a passenger has to pass through. The person to be scanned has to enter it and raise the arms. Two scans at two different positions are made by scanning the person with two beams of millimeter wave energy. The energy reflected back from the body and all items on the body is collected, measured and used for producing the 3D image. The workstation produces a holographic black and white silhouette that makes it impossible to identify a person. System options allow to additionally blur the facial features and private areas to save the passengers privacy.

Figure 8.3: Millimeter scanner, courtesy of L3 Communications

In figure 8.4 an image of the ProVision Scanner in really good quality is shown, just the head of the person blurred because of privacy reasons.

The advantage to the Backscatter X-Ray technology which is still in use is the fact that Millimeter Waves with the intensity used by the scanners is harmless to humans. The amount of radiation a person is exposed to with one scan is about 10.000 times less powerful than a cell phone. As humans emit millimeter wave

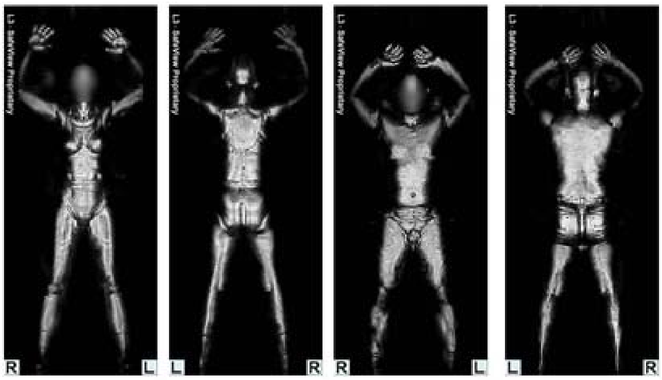


Figure 8.4: Millimeterwave Image, courtesy of TSA

radiation themselves, there exist so called passive systems too, that measure just the energy emitted by the scanned object.

8.3 Terahertz Radiation

This is radiation which has a wavelength between 100μm and 1mm and is also referred to as submillimeter radiation. It is a part of the electromagnetic spectrum, lying between Microwaves and Infrared, which was long time not as interesting as those due to the fact that terahertz radiation is strongly absorbed by the earth's atmosphere. So its usability for communication facilities is not very high as the range of the radiation is quite short. Additionally it was a big technical challenge until the 1990s producing and detecting radiation in this range.

Interest in terahertz radiation has increased due to its ability to penetrate deep into many organic materials, like clothing, paper, wood, ceramics, plastic and others without the damage associated with ionizing radiation such as X-rays. This is of interest because most materials of interest have a unique spectral "fingerprint" in the terahertz range. This offers the possibility to combine spectral identification with imaging. Furthermore it can be used to distinguish between materials of varying water content because it is readily absorbed by water like it is by metal.

There are some problems with these characteristics to be kept in mind. If a person sweats heavily or gets wet, it is not possible anymore to look through the clothing. It is also not possible to look through aluminium luggage.

8.4 Final comments

As mentioned before, all these technologies are quite problematic concerning privacy and data security. The European Parliament did not accept the concept of an order of the European Commission which would have allowed whole body scanners on european airports. The Commission was requested to discuss the topic with the European Data Security Official, to produce a cost-benefit analysis, to evaluate the health risks and to check the effect on basic rights. All within a period of three months which would end in January 2009.

Due to all found sources it seems that there was not such a big discussion in America about this topic. Although there exist few studies on the health risks and privacy might be violated, the aspect of combating terrorism is the more important one. A spokesman of American Science and Engineering, Inc. (AS&E) said that approximately 90% of the passengers preferred beeing scanned to having a pat down [38].

TSA argued that one of the advantages of Millimeter Wave scanning would be the low resolution of the pictures, so privacy would not be violated. On the other hand there exists a statement of a spokesman of Farran Technologies, an Irish manufacturer of millimeter-wave scanners, which includes that there exists technology which makes it possible to extend the screening area to approximately 50 meters. This offers the possibility of scanning people without their knowledge.

Their are other forms of trying to secure privacy. At some airports the pictures are viewed on a standalone pc in a closed cabin. The officer at the scanner has no possibility to see the pictures. It should also not be possible to store, print or transmit them, although assuring this by 100% might be hard.

Some systems show only a blurred contour of the body, some of them don't show the face for privacy reasons. The fact is that blurring the image affects the quality of the detection results too.

What it all boils down to is the fact, that for all these dispositions there are no general rules and it is very easy to undo technical changes to pictures. But as the used technologies have a high detection rate and are pushed a lot in the USA this might be the future of security checks on european airports too.

9 The Future of Image Processing on Airports

This section treats new methods applicable at airports. Three areas are considered; Facilitate orientation and movement for visitors, increased security supervise and airport tracing on ground and in vicinity sky.

Image processing can be applied in many areas. The Future of airport image processing has quite few boundaries. For example there are ideas for making airports more disable friendly. There is a Japanese company that is developing navigation system for wheelchairs. This navigation system is developed to inform persons where toilets, information desks, steps are located, to provide the user with a "barrier free" map. Other improvements and developments that are suitable for airports are "Improving the detection of low-density weapon". The new rfid-chip also creates a new application for image processing. When you check in on an airport you will receive a rfid-chip that enables person monitoring [39]. With the chip connected to a wireless network and surveillance cameras you will be monitored during the whole time at the airport. The system does not require no pre-existing infrastructure and can even create virtual floor maps in real-time suitable for emergency and security situations.

There are also the matters of airport security. Today it already exist a camera connected to short range radar that can detect movements. But this technology has its limits the object has to move above a certain speed and so forth this could be improved.

On the frontier of technology sees a new image processing system the light for the first time. Who knows what type of emotions a human is carrying on? The new system is able to read a person's face expression. The intension with system is to take and analyze photos of individuals in high traffic areas, where security is a major concern, like airports [40]. If we could take random pictures of a crowd and process them fast enough, there are the possibility to identify humans that might be problematic. The system doesn't process to whole face, but just specific sets of muscles under the face near the eyes, nose and mouth.

The improvement of detection of low quality weapons in x-rays are also one big issue that has been on the carpet after the 11 of September [41]. Traditionally, weapons are thought of as metallic guns and knives, which are characterized by a high density response in x-ray images and are consequently easily spotted by screeners. Transportation Security Administration (TSA) in USA has listed objects that are sharp like plastic, wooden, and glass as dangerous, because that they can be used as knifes. These materials are characterized by very faint, low-density responses in x-ray projections and are very hard to distinguish by screeners. First are common enhancements applied on the x-ray luggage scenes, and then an image-decluttering method called image hashing. The decluttering slices the image into different layers and different objects. Last but least the image is analyzed automatically, via the use of a newly developed metric, of various aspects of the hashing algorithm and comparison to other cluster validity measurements. The goal is to automatically select the optimum number and locations of slices, or clusters, by automatically defining threshold values in a way that results in the best quality image for the screener's use.

There are also a lot of ideas of how to monitor the air spaces with cameras and images processing. One of these systems is called "Automated Visual Control". The aim is to monitor aircraft maneuvering in nearby airport space. Instead of the preexisting, expensive lasers and GPS systems this system is based on visual identifications of airplanes by their silhouettes. The system operates also very well under conditions of low visibility like, fog, rain and snow. It operates with 2D grayscale 764×574 pixels frames and it also provides a visual detection of static and moving airplane silhouettes [42].

There are also techniques that already exist but have to be considered as new and pioneering. The risks of accidents for an airplane are highest when it still is on the ground. This is because of the limited space, high traffic, and sometimes poor visibility. To help the airport control the traffic system Advanced Surface Movement Guidance and Control System (A-SMGCS) has been developed. It key sensors are secondary surveillance radars, which rely on airplane transponders, and surface-movement radars. But the radars have limited range and reflecting obstacles makes it very difficult for a single surface-movement radar sensor type to really cover the whole airspace. The radars are then connected to a artificial intelligence system based on a network of intelligent digital cameras [43]. The system uses image-processing techniques to detect traffic and correlates and fuses data to generate a synthetic ground-situation display. The technique is already used to monitor urban traffic and works very well.

10 Image processing at Volkswagen Bratislava

In Volkswagen like in any other big modern company, production is executed by industrial robots instead of humans. There is one disadvantage of using industrial robots. It is the fact that robots don't control their work. To avoid any mistakes in the production, there are control systems in every production hall. Volkswagen is not an exception. In the Volkswagen Bratislava there is a system called FISeQs (FertigungsInformations und Steuerungssystem). This system has broad functionality. The functions of the system are:

- To assure the quality of the production
- To found defects as soon as possible
- To process increasing amount of registered construction groups
- To define control points in the system
- To process electronic results
- To provide interface between system and human control

In Volkswagen Bratislava FISeQs system is running on two types of hardware(eQs stations and Handhelds):

- eQs stations which consists of :
- industrial computer,
- tactile screen,
- barcode reader Datalogic M200 (connected with PS2 port)
- MFP reader Interflex (connected with COM2 port)
- HDT (Handhelds) CASIO DT-X10M30E which are connected on WLAN:
- Tactile screen,
- Integrated barcode reader

Figure 10.1: Handheld

This system is integrated in every of 4 production halls in Volkswagen. In the Finish-Construction hall, the Preconstruction hall, the Coachwork hall and the Painting hall, see Figure 10.2.

To describe briefly how the system globally works, let's start from the beginning. When an order comes from the customer with the special parameters for new car (car type, color, accessorize, type of wheels, interior...) the information about car specifics is divided by the production hall which executes each specifics. (E.g. Information about color is put into Painting hall group). Information corresponding to each group is than printed as a barcode, see Figure 10.3 and stuck on the torso of the coachwork.

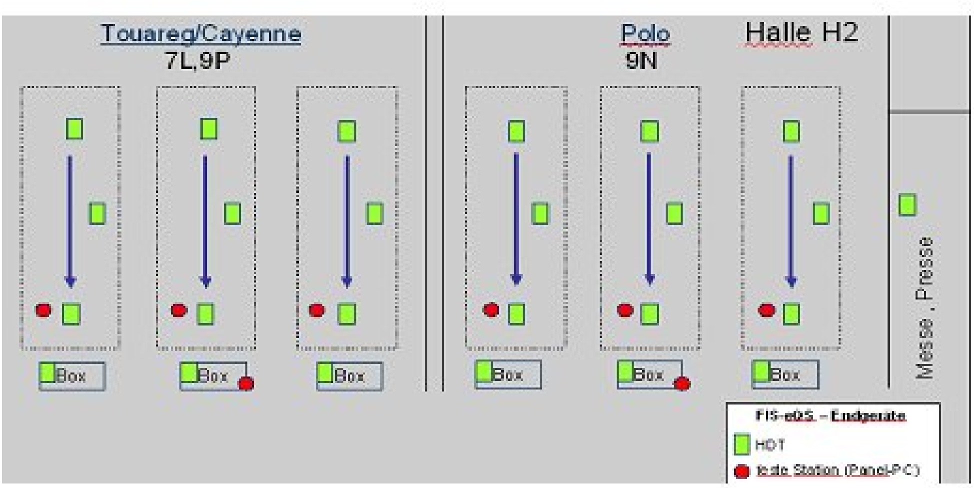


Figure 10.2: Installation of FIS system in the Painting hall (Green square- handheld station with Human inspection, Red dot- eQs station)

(a) Barcode for construction

(b) Barcode for Painting

Figure 10.3: Two different types of barcodes.

The torso of the coachwork is moved through each of the production halls. In every hall the barcode is read by barcode reader from an eQs station and instructions from barcode are executed. After finishing one stage of production, the control system is activated. There are two types of control systems in the production halls of Volkswagen Bratislava:

- Human inspection: human inspectors are controlling the correctness of production on every station in every hall (Finish-construction, Preconstruction, Painting, Coachwork), if there is any defect inspectors scan the barcode of the car by the HDT and send information about mistake to the FIS system.
- Laser control: In some halls the second system is operating. It consists of laser stations Perceptron made in USA which controls the accuracy of the coachwork by measuring the laser reflection. In case of any defects on the Coachwork, it is excluded from the production. If there are some imperfections on other components the information about them is send to the FIS system. The laser control is provided in Coachwork hall with 9 Perceptron stations and in the Finish-construction hall with 2 stations.

From the moment the torso of the coachwork enters the first production hall the car is monitored and all informations are collected in the FiseQs system. Each information about car defects, car parts, time of the finish, test and results is recorded in the system. Every defect is identified by special string which describes group, place, type and position of the defect. E.g.: 6TDR AGT modul PAS ⇒ Group: coachwork, Place: left door, Type: scratch, Position: up left.

After the finishing whole production process, the car is checked in the system. If there are some defects the car is send to the repair station. A correctly completed car is then tested and after passing the tests send to the distribution.

The Volkswagen means in German people's car and to prove this status Volkswagen Company is trying to avoid mistakes in production with image processing applications. At the end I would like to thank Mr. Stefan Dudzak who tell me about Volkswagen production and gave me the slides I have made presentation from.

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A Pictures from the baggage handling halls

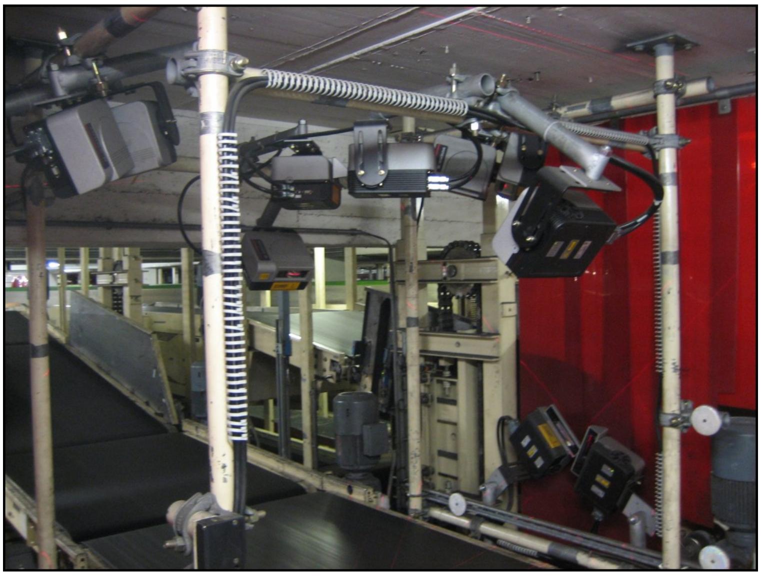

Figure A.1: Scanner that can read the baggage-tag independent of its orientation. The following conveyor part is tilted up or down (looking like $>$ from the side) dependent of which chute the bag is heading to.

Figure A.2: An equal scanner from another direction.

Figure A.3: Two chutes can be seen behind the blue carriage. Two baggage containers are also present. From the old baggage handling hall.

Figure A.4: Empty carriages in the new baggage handling hall.

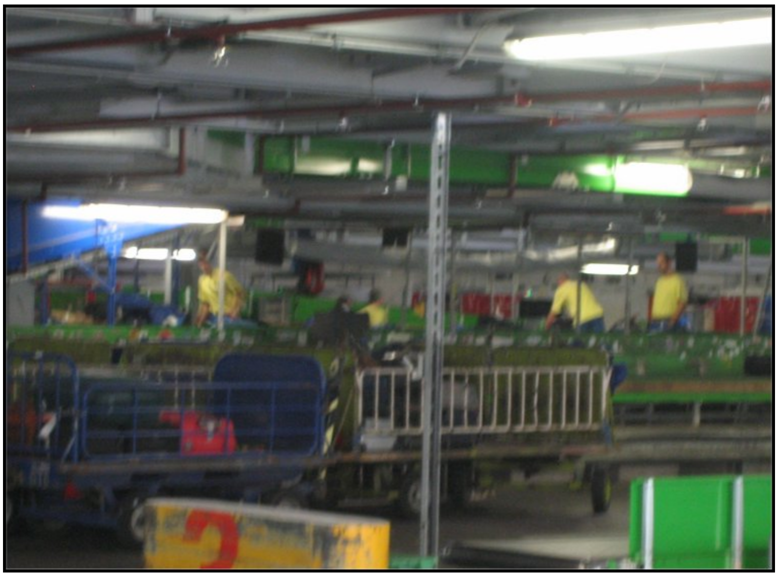

Figure A.5: Transfer luggage and huge peeks in the number of baggage are best handled by operators. Picture taken in the new baggage handling hall.

Figure A.6: Some of the conveyors consisted of titable plates in order to tilt the baggage into right chute.

B Who have done what in this report

Table 2: Table of what the participators in the excursion group have contributed to this report.

Gonzalo Mendoza Cortés	gmc.gonzalo@gmail.com	Fingerprint recognition
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Zuzanna Haladova	zhaladova@gmail.com	Image processing at Volkswagen Bratislava
Patrik Magnusson	e0826807@student.tuwien.ac.at	assembly of report Introduction The baggage handling system at Vienna airport
Daniel Moreto	moreto@gmail.com	Face recognition
Karin Straka	K.Straka@gmx.at	Whole body image
Christian Thomaschitz	chj.tom@gmail.com	Iris recognition
Fatih Ugur	e0427537@student.tuwien.ac.at	Auto ID Data Capture and Barcode Scanners
Raphael Valensi	raph.valensi@wanadoo.fr	X-Ray scanning