# NFC-Based person-specific medical assistant for elderly and disabled people

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*Abstract*—For elderly and disabled people it is totally important to develop devices, which can support and aid them in their ordinary daily life. This demands means and tools that extend independent living and promote improved health. In this work we will review the state of the art in the health assistant systems for elderly and people with disabilities. A smart nfc-based person-specific assistant system is proposed. The role of this system is providing for elderly or disabled people person- specific medical assistance. The system has the ability of identifying its interaction partner using some biometric features. According to the recognized ID the system, first, adopts towards the needs of recognized person. Second the system represents person-specific list of medicaments either visually, on screen, or acoustic, speaker. And third the system gives an alarm in the case of taking medicament either later or earlier as normal taking time.

*Index Terms*—NFC, biometrics, face recognition, fingerprint recognition, palm vein recognition, multi-modal integration

## I. Introduction

The goal of this work is the implementing of a portable assisting system which can be deployed to offer person-specific healthy support for elderly people and people with special needs in home environment. In order for an assistant system to be having the ability of providing person-dependent services a prior step of identifying the interaction partner has to be achieved. The scientific field that handles the topic of identifying/verifying the interaction partner is known as Biometrics. Person identification/verification will be achieved using special biometric systems equipped with biometric sensors, whereas the portable device could be any smart device with NFC ability.

### A. Biometrics

Biometrics means the measurement of distinguishing features and characteristics of living beings. In the present context biometrics refers to the automated measurement of physiological or behavioral features of an individual for the purpose of biometric identification and hence to distinguish it from other people.

For optimal biometric use human characteristics - whether physiological (passive) or behavioral (active) - have to be universal, unique, stable and able to be acquired technically. On the other hand biometric techniques and systems, which working with these characteristics, must be robust, accurate, safe, reliable, economic, efficient and able to be applied in life-like environments [7].

Wide range of biometrics applications are currently available on the market, under which surveillance systems, cash terminal with biometrics analysis abilities, biometrics-based payment systems[14], accessing digital systems, such as PCs, mobile phones and cars, accessing online services, such as online banking and person-specific services in home environment.

Biometrics could be used in a stand-alone mode (uni-modal) or in a fused mode (multi-modal). Fruitful avenues of biometrics modalities are being researched with the object of improving the accuracy of the uni-modal approach. Most commonly used biometric traits are face, fingerprint, finger vein, hand palm, iris/retina, and voice. Employed biometric trait differs according to the aimed application and environment. For instance, adequate fingerprint samples require user cooperation; whereas, the face and iris images can be captured occasionally by a surveillance camera. Multi-modal biometrics fuses biometric traits at diverse levels in order to improve recognition accuracy. Fusion, i.e. Multimodality, can either improve the performance of a uni-modal system, which could be degraded by noise or illumination, or reduce the number of false matches, which are caused by non-robust stand-alone biometric systems, or both. Towards our goal of building a touch less assistance system we used face, finger vein and hand palm vein to identify/verify the interaction partner. A biometric system with (multi-modal) working mode is considered in this work. Chapter II will explain the performance of each used modality and the fusion method used for join mutiple stand-alone biometric subsystems in a multimodal biometric one.

### B. Near Field Communication

Near Field Communication, abbreviated as NFC, is a subset of radio-frequency identification ”RFID” with a shorter communication range for security purposes. It belongs to the field of short-range wireless communication technology and uses magnetic field induction within the frequency band of 13.56 MHz. Due to its relatively short operating distance, few centimeters in general, and its low transfer rates (106, 212 or 424 kbps) NFC is often used as a prior step which serves for the setting up the main bulk of traffic, exp. WiFi and Bluetooth. In read/write mode an NFC-enabled device, typically a mobile phone or tablet PC, can read or write data to a supported tag in a standard NFC data format. Two NFC-enabled devices, in the peer to peer mode, can share and exchange data, such as setup parameters that initiate a Bluetooth or Wi-Fi connections, digital business cards and digital photos. NFC-enabled devices function in either active or passive mode. In the former power is drawn from modulating an external electro-magnatic field, while in the latter the device generates power of its own. Nowadays NFC technology can be seen in a wide range of applications. For example, passive NFC tags and their appropriate readers are being used as means of tracking goods along the supply chain from a manufacturer, through warehouses and distribution centers all the way up to a retailer. Personal documents, such as passports and identification cards, are currently issued with encapsulated NFC tags. Recent NFC applications, such as electronic payment and ticketing by using an NFC enabled device, demand that the user is engaged - at least partially - in the interaction, activating functions associated with tags or other NFC-enabled devices around him.

For utilizing Near Field Communication in a home environment the person has to be in complete control of both the infrastructure and the devices functioning in it. This enables a whole new level of automation and personalization of ordinary household tasks and activities. Employing Devices with NFC abilities as a medical assisting systems for elderly people and people with special needs will relieve their suffering of medical management process and promote improved health. Chapter III will give a detailed explanation of the used NFC-based medical organizer. The integration of both multi-modal biometric system and the medicine organizer in a final system will be discussed in chapter IV

## II. Multi-modal Biometric System

Uni-modal biometric systems is challenged by multiple issues, such as noisy captured data, non-universality, upper bound of identification accuracy and man-in-middle attacks. Some of these limitations of uni-modal systems can be avoided by realizing multi-modal system, which fuses input data of multiple biometric traits. This can be accomplished by fusing two (bimodal) or more biometric traits (multi-modal) at several levels. In signal fusion level data from multiple sources are fused, as example raw data obtained using multiple sensors or multiple snapshots using single sensor. Multiple feature sets, which originate from multiple feature extracting algorithms, are gathered, normalized, transformed and dimensionally reduced to build a single feature set in the feature level fusion mode. Final decisions of multiple systems can be logically fused in the decision fusion level in order to get the final decision of the multi-modal system. Fig. 1 illustrates the simple logical OR fusion method used to integrate multiple biometric subsystems in a single multimodal one.
As the aim of our work is the realizing of a health-assistant system with the ability of providing person-specific support, it suffices when the person is identified by means of analysis at least one biometric treat. That means, logically, that the decisions of applied stand-alone biometric systems (uni-modals) have to be joined using simple OR rule. Therefore, we have implemented our multi-modal system in such away, that it gives the ID of the interaction partner as soon as one or more biometric treats are recognized. From the well-known biometric treats we used face, finger vein and hand palm vein. The reason for this is that these features don’t demand any direct contact to the used sensor, which serves our goal of having a touch-less assisting system. The following subsections give small explanation of the used uni-modal system and a detailed explanation of the fusion method.

### A. Face recognition

Face recognition is one of the most populated and almost the most researched method for person authentication. Not few face recognition systems have been

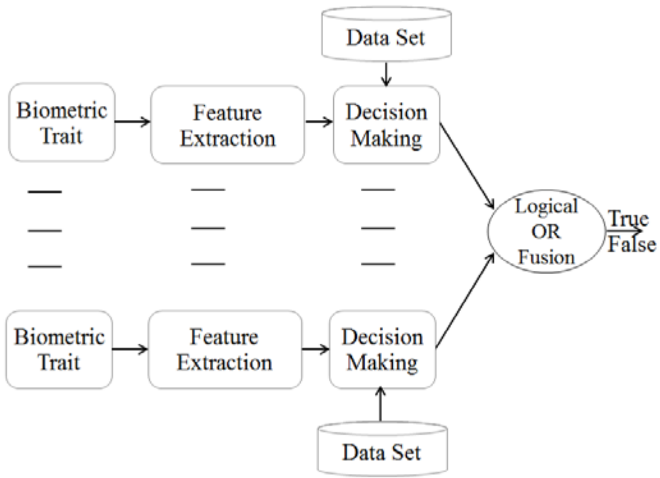


Fig. 1. Logical OR fusion method used to combine multiple biometric Traits

developed for automatically recognizing faces from either still or video images [5], [6]. For our system a robust, full automatic and real-life face-recognition-based person recognizer is employed [10]. The basic technique applied here are Active Appearance models (AAMs) First introduced by Cootes et. al. [3]. The generative AAM approach uses statistical models of shape and texture to describe and synthesize face images. An AAM, that is built from training set, can describe and generate both shape and texture using a single appearance parameter vector, which is used as feature vector for the classification. The ”active” component of an AAM is a search algorithm that computes the appearance parameter vector for a yet unseen face iteratively, starting from an initial estimation of its shape. The AAM fitting algorithm is part of the integrated vision system [10] that consists of three basic components. Face pose and basic facial features (BFFs), such as nose, mouth and eyes, are recognized by the face detection module [2]. This face detection in particular allows applying the AAM approach in real-world environments as it has proven to be robust enough for face identification in ordinary home environments [6]. The coordinates representing these features are conveyed to the facial feature extraction module. Here, the BFFs are used to initialize the iterative AAM fitting algorithm. After the features are extracted the resulting parameter vector for every image frame is passed to a classifier which categorizes it in one of the six basic emotions in addition to the neutral one. Besides the feature vector, AAM fitting also returns a reconstruction error that is applied as a confidence measure to reason about the quality of the fitting and also to reject prior false positives resulting from face detection. A one-against-all Support Vector Machine [12] is applied as classifier.

## B. Hand palm vein recognition

Typically, palm vein recognition system performs three basic tasks, namely image acquisition, feature extraction and decesion making. Image preprocessing and image enhancements could be achieved in order to get features with reliable quality for the next step of classification. For online capturing of palm vein images an M2Sys scanner is used. This device uses a near infrared light to create a vein-map of the user's palm, which serves as a biometric feature. It scans arteries beneath the skin. Therefor it is practically impossible these templates to be forged through creating someone elses biometric template. The device works in a contact less mode, in which the user has not to touch the sensor directly. For the stages of feature extracting and matching an algorithm similar to the one presented by [15] is utilized. Extracting the region of interest (ROI) from the captured palm vein image is an essential step of preprocessing. For this goal the inscribed circle-based segmentation which extracts the ROI from the original palm vein image is used. The basic step toward getting that is to calculate the inscribed circle that meets the boundary of a palm so that it can extract as large an area as possible from the central part of the palm vein image. First, an edge detecting method is uded to obtain the contour of the palm. Using the contour of the palm the biggest inscribed circle is then calculated. Once the circle is determined, ROI image is smoothed by using the standard deviation Gaussian kernel filter. In order to reduce some high frequency noise, ROI image is then smoothed by the Gaussian smooth filter. Local contrast enhancement is then applied in order to blurred ROI image caused by Gaussian filtering. For the extraction of vein-pattern-based features (vein length and minutiae) from preprocessed images a minutiae extracting method, which is basically employed in finger print recognition systems, is adopted. This method performs in four sub-steps. First, binarization is achieved using the local threshold scheme. A median filter is then used to reduce the noise. Finally, the morphological thinning method is used to thin and repair the vein line and the position information of the minutiae can be got. Minutiae based matching method, in which the position and the orientation of each corresponding couple of minutiae are compared, is based for decision making [13].

### C. Finger vein recognition

Like palm vein recognition system finger vein recognition systems consist of three basic components, namely image capturing, feature extraction and decision making. A suitable scanner, which employed infra-red technology from Hitachi, is used. This scanner captures image of the vein inside the finger, therefor the captured images are virtually impossible to replicate. The scanner works by passing near-infrared light through the finger. This is partially absorbed by the hemoglobin in the veins, allowing an image to be recorded on a CCD camera. Unless the location and the orientation of the finger within the capturing device are explicitly predefined a step of image normalization has to be conducted. Acting on the assumption that the veins in a finger vein image could be seen as lines with higher gray values as the rest of the image, the task of detecting such vein could be seen as a task of following lines within image. Line tracking offer us the ability of doing that robustly [8]. The line- tracking process starts at any pixel in the captured image. The current pixel position is called the current growth point, which moves pixel by pixel along the dark line. The direction of movement depends on the results of checking gray values of the surrounding neighborhood.

The lowest gray value of the cross-sectional profile, which represents the depth of the profile, is checked around the current tracking point. If pixel p is a neighbor of the current tracking point and the cross-sectional profile on this pixel looks like a valley bottom, then the current tracking point is considered to be located on a dark line. The angle between horizontal line and the line that connecting the current growth point and the considered neighboring pixel is called θ. I order to detect the direction of the dark line the depth of the valley is scanned with varying angle θi. The highest value of defines the direction of the dark line. After that, the current growth point moves to the closest pixel toward this direction and the process is repeated iteratively. In the case of no detecting the valley in any direction θi, then current growth point does not belong to any dark line and the tracking operation starts considering another position as current growth point. Toward detecting multiple veins in the image multiple vein tracking sequences start at various positions simultaneously. The results of tracking are stored in a matrix of the same size of the original image, which is called ”locus space”. Each entry of the matrix contains information about how much the corresponding pixel of the original image is tracked. Entries of matrix with high values means that the corresponding pixels of the original image have high probability of being belonging to a vein. The matrix is then binarized by utilizing a thresholding technique. Spatial reduction and relabeling are then applied on the binarized image in order to retain the vein line width as small as about 3 pixels in the image. Finally, a conventional template matching technique is applied to get the final decision about the between the captured vein data and the already registered one [8].

## III. NFC-Based Medical Organizer

A smart devise, might be a tablet, smart phone or microcontroller with proper peripheries. The system has the ability of reading and writing NFC tags encapsulated in the medicine packages. Additionally the system is so implemented, that it fetches entries from a pre-saved medicine data base according to the ID of the scanned medicine. The organizer gives then either feedback to the computer system in order to display the doses of the detected medicine or it displays it in its own screen. The organizer gives alarm if the time of the next taking is elapsed or if the next taking of this medicine is taking place prematurely.

## IV. System Integration

The basic structure of the whole system could be divided in two basic subsystems, namely person recognition subsystem and medicne organizer, as illustrated in Fig. 2. The former is based on the analysis of one or more biometric treats in order to identify/verify the interaction partner, while the latter is an NFC-based recognition system with the abilities of identifying the used medicine and interacting with the interaction partner.

Face, finger vein or hand palm vein data are acquired from the elderly interaction partner using a camera fixed behind the mirror or the door of the first aid box in bathroom or a finger vein sensor encapsulated within blood glucose meter or by a hand palm vein sensor hidden in a hand air dryer [1]. Once one or more of the above mentioned biometric features of the interaction partner are captured, either deliberately or accidentally, the suitable biometric features are extracted and analyzed by the corresponding person recognition subsystem and the final decision of the system is delivered as a person-ID to the medical organizer.

After the interaction partner is identified the medical organizer modifies first the theme of the interface in such a way, that it fulfills the needs of the recognized person. A list of person-specific medicines presented

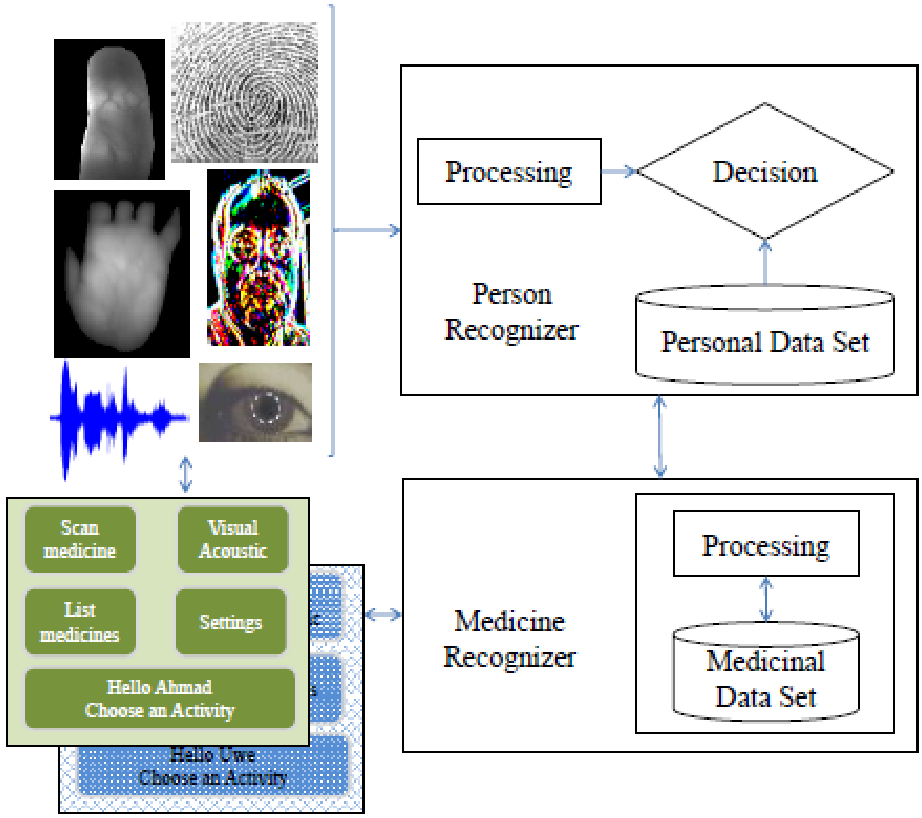


Fig. 2. Basic architecture of the medical assisting system. Person is identified by person recognizer, while medicine is identified by medicine recognizer

either visually (on the screen) or acoustically (through speaker). Via the established interface the medical will request the scanning of medicine packages from the interaction partner. A smart device or PC-tablet with NFC ability is then used to scan the the NFC tag encapsulated into the package and extract ID of this medicine. Using a prior saved medicinal data set the medical organizer presents for the interaction partner the name of the medicine, how many times it is to be taken, last taking time and if it is presently due, see the snapshot on the top of Fig. 3. The organizer has also the ability of giving an alarm if the considered medicine is wanted to be taken either too earlier or too later as the taking time point saved in the medicinal data set, the snapshots in the middle and the bottom of Fig. 3.

In practice, the biometric subsystem is implemented on a normal PC equipped with suitable biometric devices, as discussed in chapter II. For implementing the NFC-based medical organizer a nexus PC-tablet is used, see chapter III. The communication between both subsystems is achieved via TCP-connection. A synchronization process is iteratively done in order to get both person data base, which is saved on the normal PC, and a medicine data base, which is saved on the PC-tablet, synchronized permanently. When the interaction partner is identified by the biometric system the ID of this person will be sent to the tablet in order to fetch the corresponding entries of the medicine data set.

## V. Evaluation

The system is evaluated from two subgroups with four persons each. The former was a group of students in the age between 20-25 year, while the latter was a group of elderly people elder than 60 year. The reason of including the youth student is to take the familiarization with modern devices into account. Although the young group has no bodily limitations that prevents them assisting themselves medicinally, it holds such systems as useful for the modern life with much daily activities. The group of elderly people holds it as compensating for weak perception skills. Nevertheless, smooth adapting of the person-specific interface is demanded in order to overcome the ambiguity the of given feedback to the interaction partner.

## VI. Conclusion and Outlook

In this paper we presented our approach of integrating a person identification and medicine identification subsystems in a person-specific medical assisting system for elderly and disabled persons. As we strive to provide for elderly and disabled people a touch-free medical assistant system, we presented an NFC-based assisting system, which fulfills this requirement and offers for them a reliable alleviation their ordinary life situations.

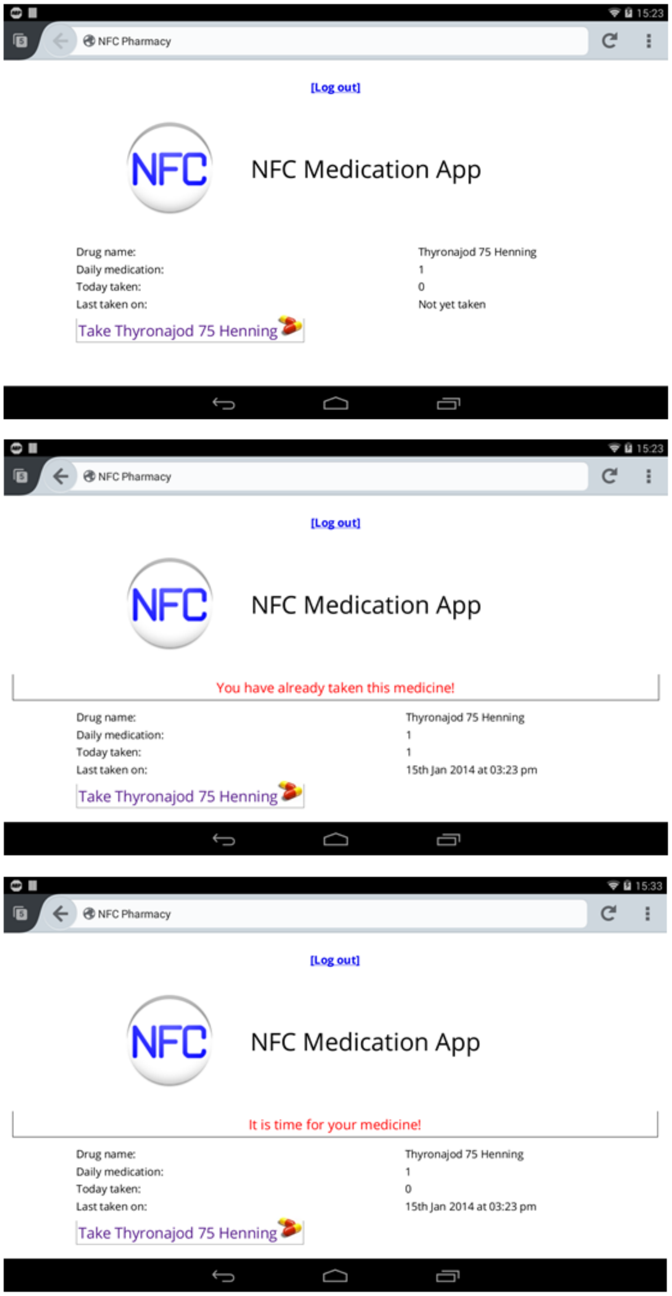


Fig. 3. snapshots of the medical organizer implemented on a PC-tablet. The figure on the top show information about the scanned medicine. Alarms as a red text are displayed in cases of too early or too late taking attempts of the medicine on the middle and the bottom figures respectively.

The results indicate that the system was useful for the target group. It provides for them a complete healthy support and relieve their warrens about the accurateness of the taken medicine and the taking time.

An open issue concerns the problem of ambiguity of the given feedback to the interaction partner, as the style of the feedback should depend on the bodily limitations of the interaction partner. To solve this problem we focus for the next step on the considering of the whole health status and the bodily limitations of the interaction partner. Another aspect is the inserting of closed loop health services within the loop, which allows for medical practitioner and pharmacist accessing the medical profile of considered people for control and support reasons [4]. Taking the analysis of affective states of the interaction partner as a feed back into account should add a reasonable improvement to the whole performance of the system [11], [9]. A future comprehensive evaluation with a larger set of test persons could validate the applicability of the system in real life conditions.

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