ENHANCING THE USABILITY OF THE HUMAN MACHINE INTERFACE ON THE HANDHELD INTERAGENCY IDENTITY DETECTION EQUIPMENT (HIIDE)

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1. Abstract

An essential element of a biometric system is the human machine interface (HMI), both from the user (administrator) and subject perspectives. The HMI has a significant impact on the performance of the system, as it is a key factor in the quality of the biometric sample collected. This paper will consider the implications of the HMI from the user perspective, analyzing the results of user experiences and training with the Handheld Interagency Identity Detection Equipment (HIIDE), a device used by the Department of Defense in Iraq and Afghanistan. The paper will conclude with recommendations and considerations for the development of future collection systems.

2. Introduction

The Handheld Interagency Identity Detection Equipment (HIIDE) is a multimodal biometric device deployed by the Department of Defense. It is capable of collecting face images as well as capturing and matching iris and fingerprint data. This document will provide a human factors analysis of the device from the user/operator perspective (as opposed to the subject's perspective - the individual whose biometrics are being collected). The HIIDE functionality (versions 4.1 and earlier) will be reviewed in detail with an emphasis on operator usability issues. Furthermore, this document will provide a task analysis and highlight key human factors design flaws and deficiencies. Lastly, this paper proposes several modifications to the device's design in order to address the identified issues.

2.1 System Purpose (Intended Use and Mission)

The HIIDE (shown in Figure 2.1) is a multimodal biometric collection and matching platform. It is capable of collecting individual fingerprints, iris and face images, as well as biographic information and photographs of identifying documents. The device is capable of matching irises and fingerprints against a locally stored watch list. Consequently, the war fighter is able to fix the identity of individuals encountered in a tactical environment. By fixing the identity of individuals, the war fighter can easily determine friend from foe, or record that information for future encounters of this individual with coalition forces. To accomplish this objective, the HIIDE must collect high quality fingerprint, iris and face images as well as perform real time matching of fingerprint and iris data. As this collection and matching may be occurring in a high stress tactical environment, these processes must occur quickly and the information must be presented to the war fighter in a clear and concise manner.

Figure 2.1 - The Handheld Interagency Identity Detection Equipment (HIIDE)[1]

2.2 Important Human System Interface and Human Factors Attributes

The HIIDE has numerous elements that are important from a human factors perspective. The list below highlights some of these major aspects that will be discussed by this paper:

- Device Form Factor
- Biographical Information Data Entry
- Quality Control of Biometric Capture

2.2.1 Device Form Factor

As a tactical element carried by the war fighter, the device must be lightweight and small in size. One of the major design requirements was that the finished HIIDE product fit in the pocket of a standard Battle Dress Uniform (BDU). Furthermore, the entire system weights only twelve ounces making it practical for the war fighter to carry in the field [1]. It requires two hands for operation – both for data entry (one hand to hold the device, one to enter) and for data collection (two hands required to steadily hold the device up to the subject).

[1] http://www.aditech.co.uk/img/HIIDE.jpg

2.2.2 Biographical Information Data Entry

A user interface is provided to enter biographic information into the device. A small (3x2 inch) touch screen and a stylus are used as the primary means of data entry in the field, as shown in Figure 2.2. However, errors in touch screen interaction can make data entry difficult. To further complicate matters, gloves are a common accessory to the BDU which makes precise touch screen contact cumbersome and often inaccurate. To use the device to its full operational potential, information regarding the context and circumstances of the encounter with the subject must be collected and accurately recorded by the war fighter in the field. Currently, the only alternative to using the stylus and touch screen is connecting the device to a docking station through the use of a laptop and Graphical User Interface, which are not typically carried in the field.

Figure 2.2 - The HIIDE Touch Screen User Interface[2]

2.2.3 Quality Control of Biometric Capture

All biometric systems require high quality data for optimal performance [2].In the HIIDE system, the quality control element of the biometric data collection is in the hands of the device operator. Furthermore, the quality control mechanism varies by the biometric modality being collected.

- Fingerprint
  - Fingerprint images are captured one at a time by a single finger sensor embedded on the top of the device. The system prompts the device operator which finger should be presented. Finger description examples are 'right index' or 'left thumb'. This approach may lead to operator confusion or error

[2] http://www.l1id.com/pages/47-hiide-series-4

(is the system requesting the operator's right? Or the subject's right?). The system has no way to check to ensure that the fingers have been entered in the requested order. Incorrect entering of the fingerprints may lead to false non-identifications when 'binning' is applied to the matching process. Binning is a technique used to decrease the number of match scores calculated. While exact speed gains vary depending on the number of bins used and data collection method, binning is a widely employed method to reduce response times [3, 4, 5, 6].

- Operators initiate the biometric capture of the fingerprint through the touch screen interface while the subject places his or her finger on the sensor, located on the top of the device. Figure 2.3 depicts this interaction.
- During fingerprint collection, the device does not allow an operator to proceed with image capture until a minimum quality threshold has been surpassed. Once this threshold is passed, the quality is indicated by colored bars on the sides of the screen. The operator can choose to collect an image of any quality above the minimum. To improve quality, the operator can clean the fingerprint platen, clean the subject's finger or pay special attention to the subject's placement of the finger on the device. The selection of a 'good enough' quality image resides in the hands of the operator. The operator can choose to capture an image, despite a low quality indicator if it has satisfied the minimum quality threshold.

Figure 2.3 - HIIDE Fingerprint Collection Method[3]

- Iris
  - Iris images are collected one at a time by a Near Infrared (NIR) sensor that provides streaming video to the operator and a real time quality metric. The quality metric is provided visually to the user by colors bars on the side of the touch screen. These colored bars indicate high (green) or low (red) quality scores for the previously captured image (if an eye cannot be located, no bars are displayed). The bars vary in size to convey a relative metric of the quality to the user. Two full green bars on either side of the screen indicate optimum quality. Figures 2.4 and 2.5 highlight the colored bar concept for both high and low quality images.
  - The selection of a 'good enough' image resides in the hands of the operator. The operator can choose to capture an image, even if the system is providing a low quality indicator. After the collection, the system will indicate to the operator if it was unable to locate an eye. If an eye was not located, an error message appears, the image will not be stored and the operator has the option to attempt another collection.
  - To collect an image, the operator must press buttons located on either side of the top of the device, using their right or left index finger. To capture a high

[3] http://archive.redstate.com/stories/special_features/hiide_and_seek

quality image requires the operator to hold the device at subject eye level, with minimal vibration or movement, and press the collection button. However, the very act of pressing the capture button may introduce motion blur or other artifacts that impact the quality of the iris collection.

Figure 2.4 - Good Quality Iris Indication[4]

Figure 2.5 - Poor Quality Iris Indication[5]

- Faces
    - The quality face image capture scenario is similar to that of the iris collection scenario. The operator holds the device at face level and presses the capture

[4] http://www.defensenews.com/pgf/stories25/100409at_biometrics_800.JPG
[5] http://www.defense.gov/dodcmsshare/newsphoto/2007-06/hires_070601-A-9326H-024.jpg

button. The operator has the ability to capture five images of the subject: frontal, right profile, 45 degree right, 45 degree left and left profile. Facial quality measurements are computed and take environmental factors, such as scene lighting, exposure and illumination into consideration as opposed to iris quality measurements which evaluate image blur, resolution, and focus. Following the collection, the operator is alerted if an image of insufficient quality was collected and the data will not be enrolled. Poor quality metrics indicate to the operator that they should reconsider their collection environment (for example, move to avoid harsh sun angles).

2.3 System Functions

The HIIDE has three primary functions: enrollment, match, and upload/download.

- Enrollment
  - During the enrollment function, the HIIDE device will collect fingerprint, iris, face, document and biographic information as provided by the operator. The device creates a new record for the subject, giving the enrollment data a unique ID. The device also records a time/date stamp for inclusion in the enrollment record. This information is packaged and stored according to the standard Electronic Biometric Transmission Specification (EBTS) onboard the local device to await upload to an authoritative master database.
- Match
  - During the matching function, the HIIDE device will collect fingerprint and iris information as provided by the operator. The device uses the information provided to search the local onboard watch list for fingerprint or iris matches.
    - If a match is found, the matching record information is provided to the operator.
    - If a match is not found, the operator is offered the opportunity to enroll the data. If the enroll function is selected, the operator is prompted to collected the remaining subject information and the function proceeds as described above.

        - Records of all matches are stored locally and later uploaded to the authoritative database in order to provide universal subject encounter records.
        - Some versions of the HIIDE support biographic match. This function relies upon the proper spelling of the subject's last name.
- Upload/Download
    - During the upload/download function, the device is docked to a workstation that provides network access to the authoritative database. The device provides functionality for uploading newly enrolled records and recent match encounters. The device also has the ability to download new or updated releases of the watch lists.

3. Task Analysis

A task analysis was conducted to consider the process associated with the mobile collection of face, finger and iris biometrics. This information was used to identify potential design optimizations than could be applied to minimize user error, enhance usability and improve the quality of the collected data.

Task data was collected via three primary methods: observation, unstructured interviews and personal experience. The types of users observed and interviewed ranged from novice users with no biometric experience to engineers with advanced biometric understanding. The familiarity level also varied widely from individuals who had just been trained to those who have been using the device operationally in the field for extended periods of time. Data has been sporadically collected over four years. The task analysis indicates that there are five key device tasks:

- Device activation
- Collect biometric data for matching
- Analyze match results
- Collect biometric data for enrollment
- Upload/download synch from authoritative database

The human is an essential element of the HIIDE tasks. Major functions of the human:

- HIIDE Function Decision – The operator provides the function direction to the HIIDE (enrollment, matching or upload/download) and controls the transitions between each function.
- Data Collection – The operator is key to the collection of biometric data. The operator must position the subject and the device appropriately to capture a high quality face, iris or fingerprint image.
- Acceptable Quality Determination – The operator provides the ultimate decision regarding the quality of the face, fingerprint or iris image to be stored. It can override poor quality indicators provided by the HIIDE.
- Data Entry – The operator must enter the biographic and contextual encounter information for the HIIDE to function. Without this information, the HIIDE simply provides a match to a biometric record – a task that is not useful when databases are co-mingled with friend and foe data.
- Decision Processing – The operator processes the match decision provided by the HIIDE (Figure 3.1) by considering the quality of the match and the contextual information before determining how to proceed with the situation. The HIIDE essentially provides only a red or green light (match or no match).

In the following section, the authors identify weak elements of the system design and suggest alternatives to improve the performance of the device, the usability of the system and the quality of the data acquired from the device.

Figure 3.1 – Match Decision Divided by HIIDE[6]

3.1 Decrease of Sequential Task

3.1.1 Deficiency

Tactical biometric platforms are likely to be used in stressful environments, such as following military operations or at checkpoint locations. Sequential tasks should be eliminated to reduce the time and attention required to operate the device.

3.1.2 Proposed Redesign

Removal of the requirement to enter biographic and contextual encounter information during the initial collection will minimize the time spent with the subject. Much of this information can be acquired through the collection of the identity documents carried by the encountered subject. An Optical Character Recognition (OCR) and Machine Translation schema could be implemented to automate the process of completing the biographic fields. This process would occur post encounter (possibly on the docking station) to minimize processing requirements onboard the HIIDE device that may impact collection performance. A sample workflow for this process is outlined in Figure 3.2.

[6] http://www.l1id.com/pages/774-hiide-5

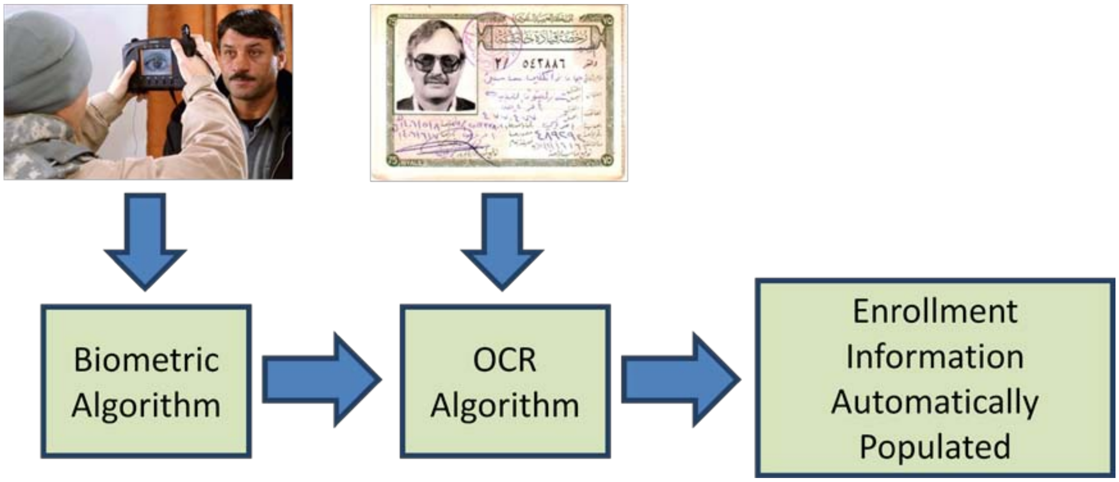

Figure 3.2 - Workflow of Biometric Enrollment using OCR Algorithm

The addition of a microphone and 'hot button' for activation will allow the operator to make brief comments regarding the context of the encounter during collection. At some later time, this recording could be reviewed by the operator as a reminder of the encounter's situational information. This may also increase the quality and quantity of the contextual reporting, enhancing encounter records and supporting coalition forces in any future interactions with the subject.

3.2 Capturing High Quality Biometric Data

3.2.1 Deficiency

The tasks associated with capturing a high quality face and iris image of the subject require patient and well-trained users. Under stress, a user may cut corners and not follow guidelines for ensuring optimal quality data collection. Poor quality data results in poor overall system operation (the principle of garbage in, garbage out). One particular study conducted at West Virginia University indicates that by removing poor quality data from enrollment databases, error rates drop by a factor of six [2]. Techniques to minimize the user tasks and skills required to capture a high quality iris or face image with the HIIDE system would likely produce similar results.

3.2.2 Proposed Redesign

Currently, human skill is required to capture a high quality image of the face and irises. Quality control can be automated to remove the human performance requirements. The operating device calculates the quality of face and iris images in real time and provides this information to the operator for selection (pictorially displayed as quality bars). An alternate approach is to allow the device software to collect a stream of video of the face, iris or document collection. The device then analyzes each frame (or every n^{th} frame) to generate a quality score. The image(s) with the top quality are selected and used for matching or stored for enrollment. In the event that an image of sufficient quality is not obtained, the operator will be notified. The operator will then have the option to retry using automatic selection process (video stream) or use the default manual process where quality selection decision is solely in the hands of the operator.

3.3 Reduce Collection Errors from Mishandled Data

3.3.1 Deficiency

Because of the single finger and iris collection sensors, the operator must proceed through the collection one digit or eye at a time. The operator is prompted to obtain the subject's left hand or right hand fingers. This method is prone to operator error such as collecting what is the operator's left as opposed to the subjects left digits (and vice versa). Similarly, the order of the digits is often confused as the operator fumbles with the clumsy device to prompt collection. Because only a small area of the print is collected, it is impossible to determine the correct ordering of this information post collection. A similar scenario occurs during the collection of iris images. The operator confuses the subject right with the operator's right and inadvertently mislabels the data. In one study that investigated non-battlefield fingerprint systems, researchers found that enrollment information was mislabeled approximately five percent of the time [3]. One must assume that battlefield and other high street areas have even greater error rates. For this reason, efforts must be made to reduce the likelihood of these errors occurring during the collection process.

3.3.2 Proposed Redesign

Although these error can be overcome by exhaustive searching of the fingerprint or iris dataset (as opposed to binning by finger or eye), this may not be a feasible solution because it significantly increases the processing required to perform an exhaustive (1:N identification) search of the authoritative database [4, 5, 6]. An alternate approach is to collect both eyes simultaneously or multiple fingers at one time.

- Fingerprint Redesign: To redesign the fingerprint collection mechanism, a ‘slap’ collection device can be incorporated into the platform in place of the single finger device. A slap collection device, as shown in Figure 3.3, requires the subject to place or ‘slap’ all left fingers onto a large platen for simultaneous collection, ‘slap’ all right fingers onto a large platen for simultaneous collection, and finally place the two thumbs on the device for collection. When using this method, it is nearly impossible to move the fingers from their correct order. This device is also capable of automatically identifying missing digits – a process that is often a source of error in single finger collections.

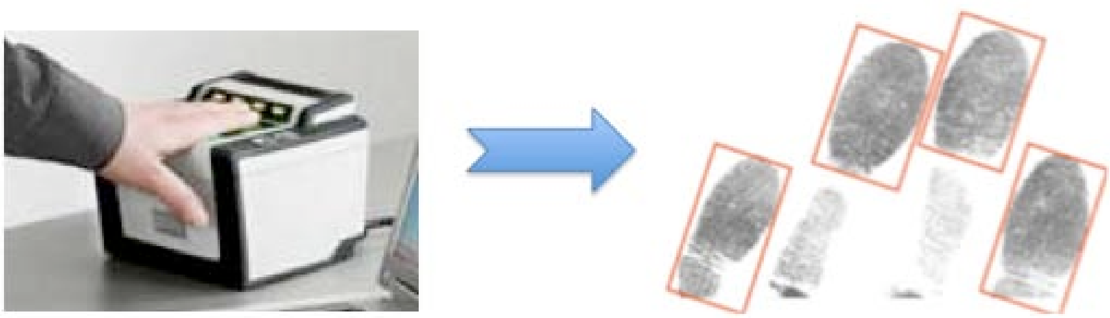

Figure 3.3 - Example of Slap Fingerprint Collection Method[7]

- To minimize the impact on the size of the device, the touch screen used to enter information, view results and define the system functions can be modified to serve the dual purposes of user interface and fingerprint collection. Fingerprint collection will only occur when the collection function is activated. During this time, the touch screen functionality of the device will be disabled, allowing the screen to serve as a large slap collection mechanism without increasing the special needs of the overall system.

[7] http://www.nist.gov/itl/iad/ig/fpvte_2003_plan.cfm

- Iris Redesign: In order to avoid mislabeling iris data, a dual iris sensor can be incorporated. This sensor requires a wide field of view, capable of encompassing both eyes of the subject simultaneously. A preprocessing algorithm will be applied to parse the left and right iris images from the large frame for enrollment and matching. An example of this capability is demonstrated by Figure 3.4.

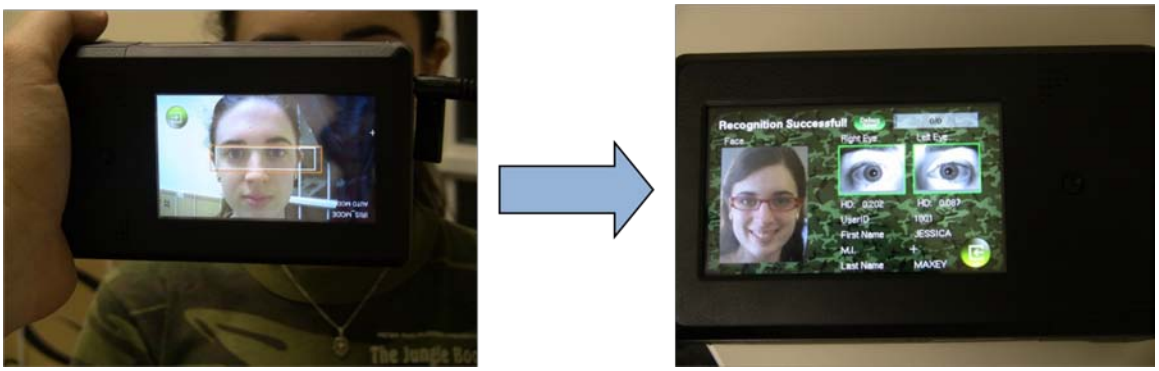

Figure 3.4 - Example of Dual Iris Sensor

3.4 Modify Device Form Factor to Improve Ease of Use

3.4.1 Deficiency

The bulky design of the HIIDE unit requires two-handed use for collection of biometric data as demonstrated in Figure 3.5. The weight balance makes single-handed collection nearly impossible. Minimizing the weight and size requirements can decrease the impact on the operator required to carry the device.

Figure 3.5 – Two Handed Iris Scanner Design Used by HIIDE[8]

3.4.2 Proposed Redesign

Improvements in technology since the release of the HIIDE will now allow the device size and weight to be reduced. The cell phone industry has spurred the development of small, lightweight high quality lenses and imagers that will be incorporated for iris, face and document capture. Touch screen technology has also improved in performance, size and weight since its introduction into the cell phone market. These technology improvements will be incorporated into the new platform to minimize the size and weight of the device.

The device can also be redesigned to operate with one hand as shown in Figure 3.6. The weight distribution will be moved to one side (presumably the side of the hand operating the device). This movement of the center of mass will enable the user better single-handed control and stability of the device. The device will allow operation via either hand to accommodate left- and right-handed operators. To switch hands, the device will be turned over so the center of mass resides in the dominant hand. The device can identify its position and adjusts the touch screen and imager accordingly (flip to be readable by operator). This is possible through the addition of accelerometers.

[8] http://troopscoop.typepad.com/updates/2010/05/24/index.html

Figure 3.6 - Single Handed Iris Scanner Design

4. Conclusions

The Handheld Interagency Identity Detection Equipment (HIIDE) is a useful device for fixing the identity of friend & foe for the war fighter. The above analysis highlights design weaknesses that can be modified to improve the function and operation of the device as well as to simplify the Human System Interface. Incorporating these design suggestions in the next generation of mobile biometric collection devices will vastly enhance the system's usability, making it easier for the war fighter to collect high quality biometric information. Higher quality data greatly increases the likelihood that these systems return accurate identification, keeping our law enforcement and military informed of an individual's identity so they can effectively carry out their missions and return home safely. A HIIDE v.5.0 was released in July 2010 that addresses some of the design suggestions described above. The device remains under evaluation; the authors look forward to future analysis of the impact of these HMI modifications on device operation.

5. References

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