Identifying “De-Identified” patients by their faces: what are the Implications of Surface-Rendered Facial CT Images for Patient Privacy?

Three-dimensional and multiplanar reconstruction of CT images has become routine in diagnostic imaging. The technology also facilitates surface reconstruction, in which facial features and, as a result, patient identity might be recognized.

There is a potential risk of violations of patient privacy rights.

This article summarizes a study undertaken to assess whether volunteer viewers can recognize faces on 3D reconstructed images as specific patients.

Our research project was inspired by a recent, provocative lecture at the US National Cancer Institute. A National Institutes of Health lawyer gave a presentation on the importance of patient privacy when cross sectional imaging studies are used for research, educational, and even for clinical applications.

One of his major take-away points was a suggestion that “it is impossible to de-identify patient faces and so images containing a significant portion of a patient’s face can never be utilized for research, education, or sent via the Internet without full encryption even if the patient’s identifying metadata are removed”.

The rationale for this was related to the capability of an increasing number of “advanced” imaging workstations to render a high resolution, surface reconstructed image of a patient’s face that closely corresponds to a recognizable photograph of that patient.

This suggestion has major implications for existing public and privately held, shared repositories of research images in brain, head and neck, and the face in both CT and MRI, especially those that are stored in DICOM format. It also has potentially important implications for educational materials such as teaching files and even clinical files that have been de-identified in DICOM for patient privacy reasons.

Somewhat surprisingly, the premise that patients could be identified by their 3D surface rendered facial reconstructions had never been tested experimentally. This formed the basis of our research project which was designed to determine the ability of observers to identify a person based on the reconstructed image of their face.

Study Design

The study was conducted prospectively and included the following “subjects” all of whom consented to participate in this IRB approved study [1].

1. Twenty nine patients who were referred to our department for a CT that included their face agreed to have a photograph taken of their face and to also have a 3D surface reconstruction created from their thin section CT images [Figure 1].

2. One hundred and fifty patients who presented to the department agreed to have photographs taken of their faces to serve as images to be used as...
possible (but incorrect) selections in a multiple choice matching quiz to be matched with the CT surface reconstructed images obtained on the twenty nine patients mentioned above.

3. One hundred and forty nine people took the quiz which asked these observers to match the photographs with one of the twenty nine 3D surface reconstructed images.

The face matching quiz was administered to the 149 observers using a web-based questionnaire that required each to register on the website and provide informed consent for their role as observers. Each observer was presented with a randomly selected set of 58 questions in which he/she had to match the 3D reconstructed image with a group of photographs [Figure 2]. In half (i.e. 29), of the questions, one of the photographs was guaranteed to match the 3D image.

In the other half of the questions, one of the choices was “none of the above” and a match was not guaranteed. Thus each of the 29 patients was presented twice with random photographs to be matched, sometimes with the correct photo included as a choice and sometimes not. Thus the task in the quiz required the observers to not only pick the closest match in half of the questions but to also decide in the other half of the questions whether any of the photographs matched the 3D image of the face at all.

The majority of the 29 patients who underwent both a CT scan of the face and had a photograph taken (16 or 55%) were African American and the remainder were Caucasian. Their average age was 56 and 24 were men and 5 were women (reflecting the gender distribution at the Baltimore Veterans Hospital).

Of the 150 patients who had photographs of their face taken in order to serve as incorrect choices on the quiz, 62% were African American. This group included 130 men and 20 women and their average age was 54.

The group of image reviewers consisted of a variety of healthcare and non-healthcare professionals and were predominantly Caucasian (64%), but also included Asians (24%) and African Americans 9%.

RESULTS

Overall, the 149 people who took the quiz had an average score of 61% correct answers. This meant that in approximately 3/5 questions they were able to select the correct matched photograph for the 3D image of the face or were able to correctly state that none of the photos was a match. As we expected, performance on the matching quiz was much better (88%) when the observers knew that one of the photos was a match. They did much worse (only 50%) when the correct answer was “none of the above”. Differences in age and sex had minimum impact (younger and male observers did slightly better) but ethnicity of the reviewer was highly significant when the person taking the quiz was the same as the person who underwent the CT scan with facial reconstruction.

DISCUSSION

The study provided several interesting results that are important when considering the potential liability associated with sharing supposedly “de-identified” cross sectional images for research or educational purposes that include the face.

The first is that it is indeed correct that observers can, with a relatively high degree of accuracy (88%) find the best match for a 3D reconstructed image when presented with several patient photographs selected randomly.

This task would have undoubt edly been much more difficult if we had made all of the selections of the same ethnicity, which was not done. On the other hand, this matching is a difficult task when it is not certain whether any of the possibilities are actually a match for the 3D image, as would be the case in a clinical situation.

Also, clinically, it would likely be more difficult to recognize a patient without their photograph available for side by side comparison. Apparently, the differences in facial expression and positioning while being photographed and scanned make this task more difficult as does lack of cues for recognition such as facial and scalp hair, skin color ation, etc. It was not surprising that persons of the same ethnicity were better at matching a 3D image with a patient photograph, which we had intuitively anticipated.
Our research further inspired two additional research projects. The first was whether a computer algorithm using a facial recognition technique would be able to perform as well or better as a human observer.

The second was whether it would be possible to “mask” a CT or MRI study that includes the face to make it more difficult or impossible to identify the patient.

The first study was published in the Journal of Digital Imaging in 2011 and utilized the same CT and photographic data sets as for our 3D facial recognition study [2].

In this study, image matching was performed using Google’s Picasa 3.6 facial recognition software. In this study, the software was able to recognize all but one of the 3D CT reconstructed images as an image of a face. However out of either 50 100, or 150 photographs, the software was only able to match 8 of the 29 3D reconstructed images of the face with its corresponding photograph. It did not produce any false positive identifications but was unable to select a match in the remaining 21 out of 29 cases for a total success rate of only 28% in performing the match. This was much lower than the human accuracy rate which was approximately 57%.

Since 2011, facial recognition software has progressed substantially and it would be interesting to determine whether current programs such as Facebook’s Deep Face software which claims a 97% accuracy rate for facial recognition would perform better. Additionally current facial recognition software is not optimized for matching with a 3D reconstructed image of the face but it is quite possible that in the future such software could be optimized or trained for this task.

At the 2011 annual meeting of the Radiological Society of North America, we presented a paper that explored a novel technique for creating a “mask” over the face that effectively prevented recognition of a face by a human or computer facial recognition program [3]. We believe that this type of facial masking can be used to effectively overcome HIPAA and other patient privacy concerns about the potential for identification of a patient using his/her face in an otherwise completely de-identified patient study.

CONCLUSION,

Our research has investigated and highlighted a potential major issue that applies to research and educational repositories of medical images in DICOM or potentially other formats which include the face.

We have demonstrated that both humans and computer programs can, with varying success, match reconstructed images of a patient’s face with a corresponding photograph of that patient which suggests that a patient could be identified on this basis alone.

This would then seem to confirm that educational, research, and clinical transmission of patient studies that contain substantial portions of a patient’s face require additional efforts in order to maintain patient privacy in addition to deletion or suppression of metadata such as patient name, identification, address, age, and other identifying parameters. Furthermore the HIPAA prohibition against images comparable to a photograph of a patient’s face would seem to suggest that the images themselves need to undergo a form of masking or other modification in order to preserve patient privacy due to the ubiquitous ability to create 3D surface rendered images of a patient’s face. Future enhancements to facial recognition software are very likely to improve computer assisted identification of a patient based on a reconstructed image.

The good news is that facial masking techniques can be used to modify these images in such a way that the underlying diagnostic images are fully preserved while negating the ability to create a recognizable image of the face.

REFERENCES
1. Chen JJ et al. Implications of surface-ren-