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Interactive Wound Synthesis on 3D Face Using Inverse Projection Mapping

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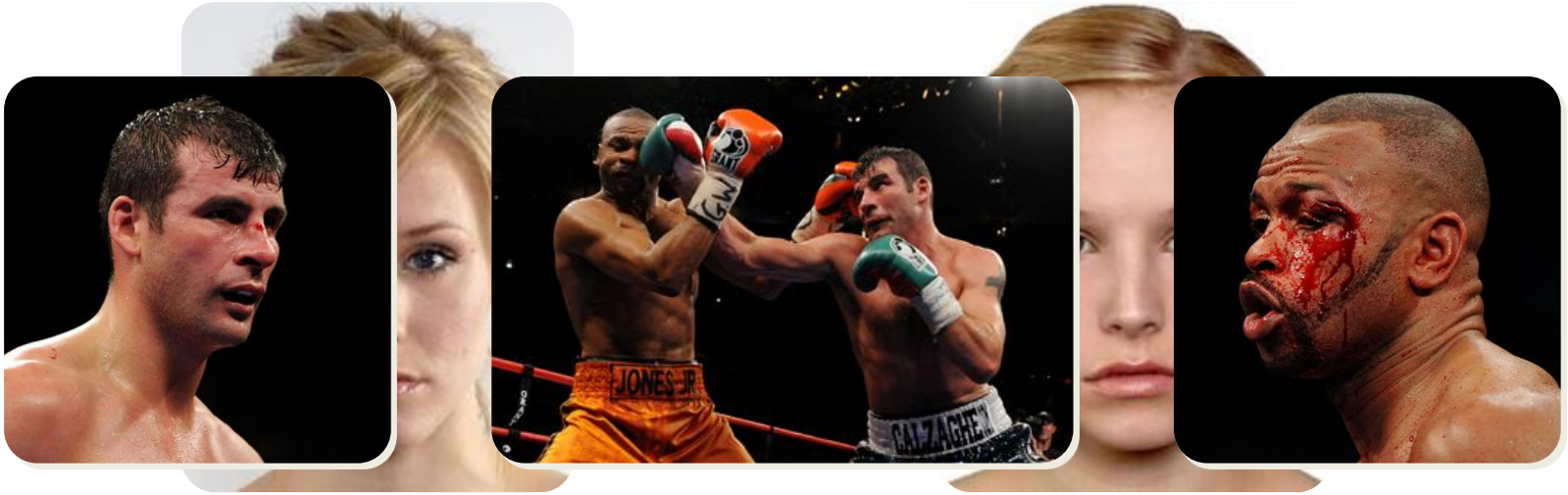
Introduction

- Motivation
  - Recently, a human-like face of 3d characters has been sporadic in the fields of movies, games, agents and animations.
  - However, super-realistic appearances such as a method of realization of wounds or scars on the face have not been paid attention in the research fields.
  - Most approaches seem to be mainly contingent upon manual work done by designers.

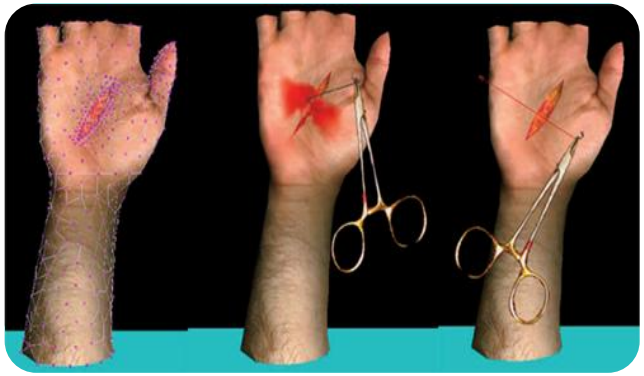


Introduction

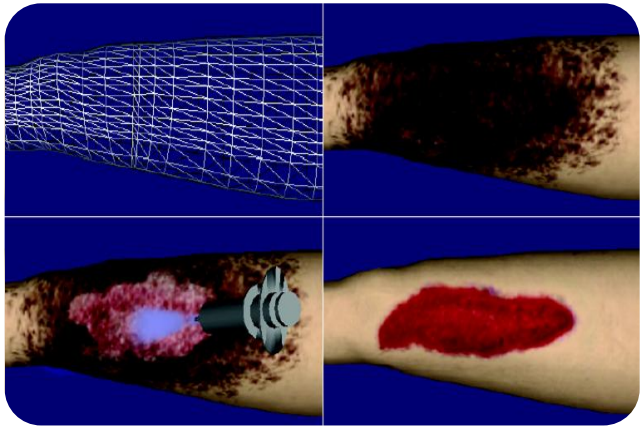
- Motivation
  - For instance, at the computer game, as rounds passes, the face of character can be hurt caused by opponent's attack such as kicks, punches, gunshot, and so on.
  - In this scene, we are not able to feel genuine nuance as realistic as possible without realization of wounds on the face of character even though the face has high quality as almost same as a real human face.
  - Hence an easy and novel method to realize wounds on a 3D face is required.

Related Works

- Jeffrey Berkley et al., 2004.
  - Analysis on suturing processing of surgical operations
  - Simulated in computational model using finite element model.



- Shen et al., 2006.
  - presented a virtual treatment training system for removal of debridement on wounds.



Related Works

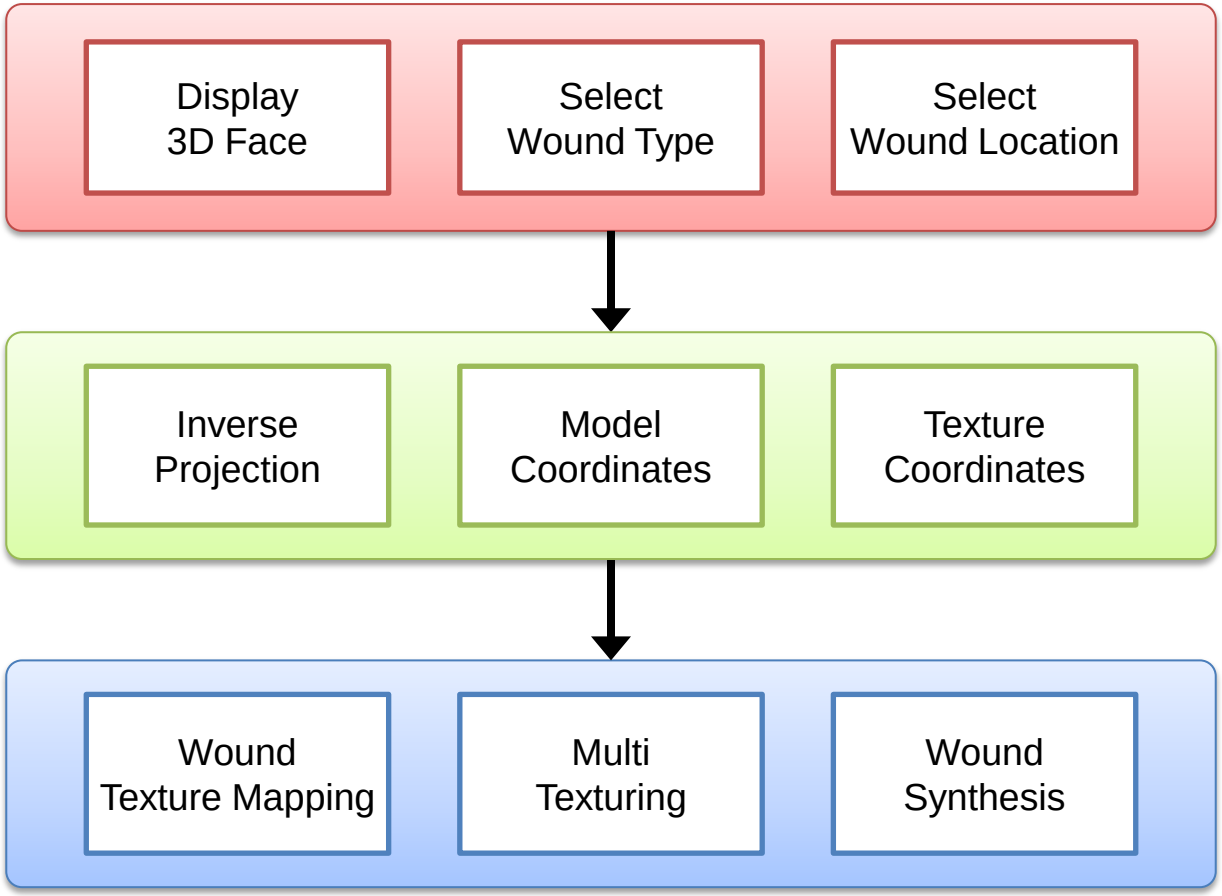
- Peter Oppenheimer et al., 2002.
  - Compositing local surface features of cutaneous wounds onto 2d / 3d patient models
  - The wound database is generated from clinically captured photographic images
  - Extracted wound images using Adobe Photoshop and attached the images onto 3d patient model made by using a 3d authoring software (3DMeNow)
  - However, the approaches seem to be not fully automatic and user-friendly.

Research Objects

- A method of interactive wound synthesis on 3d human face model.
- First, users select the type of wounds and location on 3d face model.
- The algorithm automatically derives it's 3d model coordinates from the pointed spot on 2d windows systems.
- After that, the wound image have to be mapped to the specific area that is surrounding the selected polygon of 3d face model.
- Developing the wound synthesis system and simulate the wounds-implemented 3d human face model.

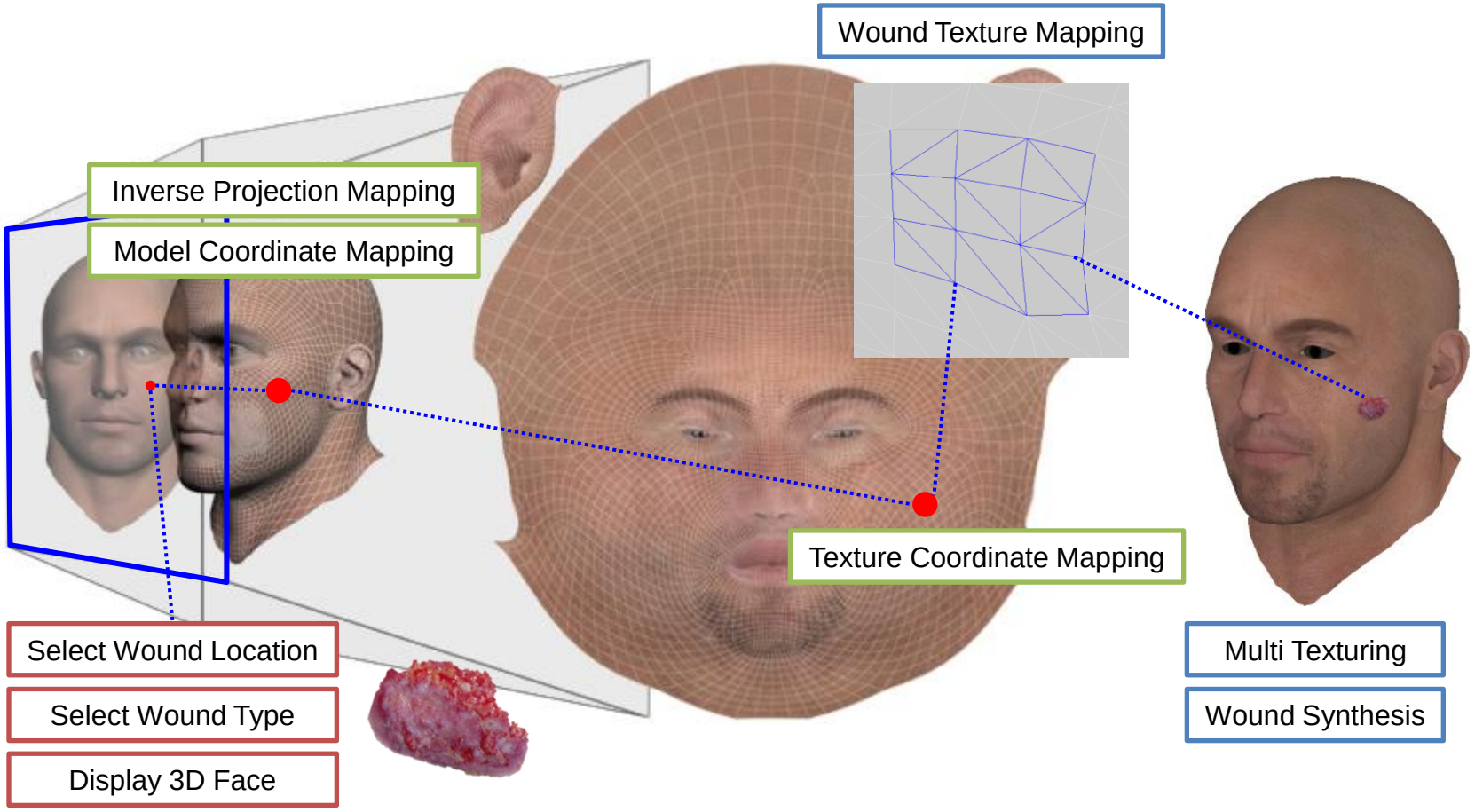
Methodology

- Schematic Approach



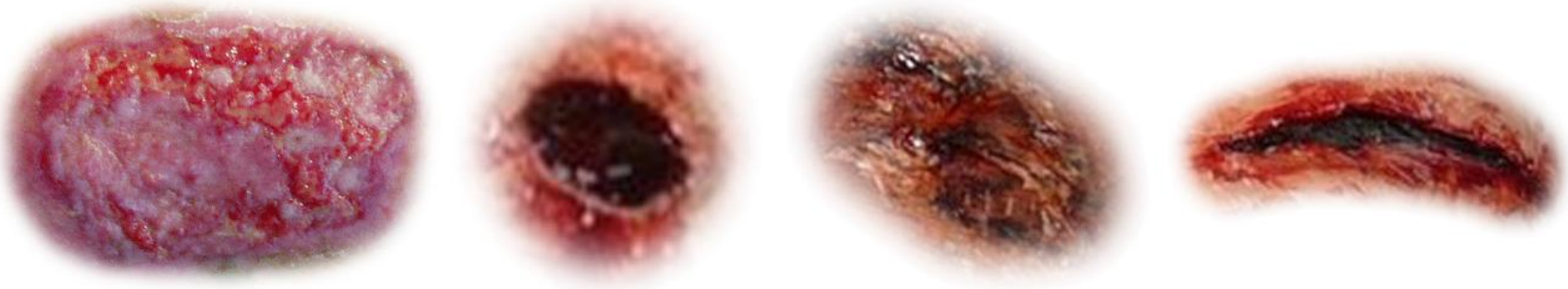
Methodology

- Schematic Approach



Methodology

- Wound Texture Images
  - The wound images are required to synthesize different types of wounds.
  - It consists of diverse wound images including abrasion, stab, burn, incision, and so on.
  - At first, we gathered wound images by taking pictures or capturing web contents and classified them into the types of wounds.
  - After that, all images were segmented to extract the wound area from the surrounding skin with blended outline.



abrasion stab burn incision

Methodology

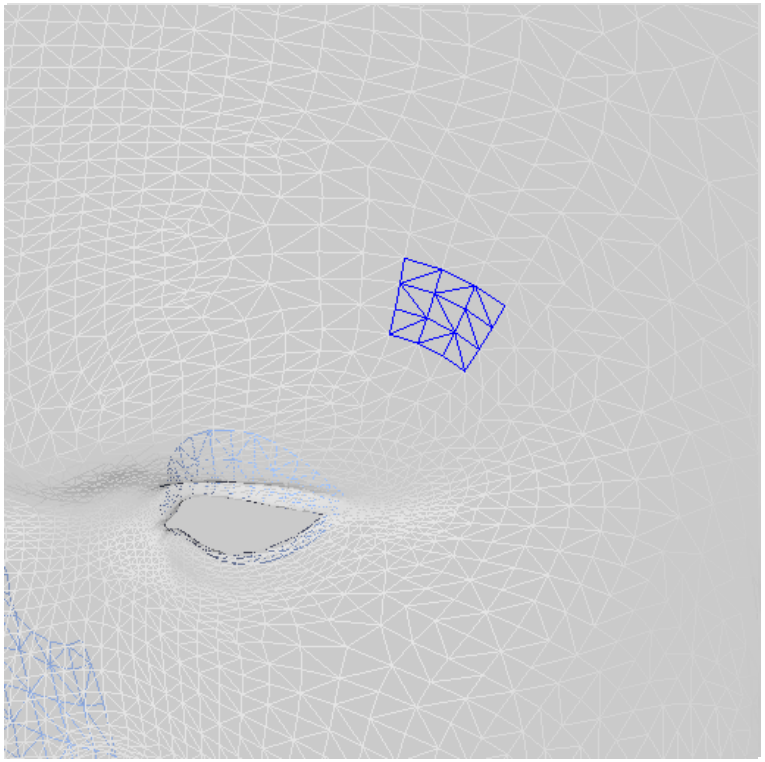
- Inverse Projection Mapping
  - The computer monitor is 2d surface and the face model is a 3d scene.
  - To make it possible for the user to easily choose the 3d position of wounds on the face model using only simple mouse handling, the 2d screen coordinates must be transformed into the 3d world coordinate system for the face model.
  - We can get the transformed 3d coordinates by using the inverse matrices of perspective projection and viewport transformation as in the next equation.

- $P' = (NV)^{-1} P$
  - P': 3d coordinate, P: 2d coordinate
  - N: perspective projection matrix
  - V: viewport transformation matrix

$$N = \begin{bmatrix} \frac{2n}{r-1} & 0 & \frac{r+1}{r-1} & 0 \\ 0 & \frac{2n}{t-b} & \frac{t+b}{t-b} & 0 \\ 0 & 0 & -\frac{f+n}{f-n} & -\frac{2fn}{f-n} \\ 0 & 0 & -1 & 0 \end{bmatrix} \quad V = \begin{bmatrix} \frac{w}{2} & 0 & 0 & l+\frac{w}{2} \\ 0 & \frac{h}{2} & 0 & b+\frac{h}{2} \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

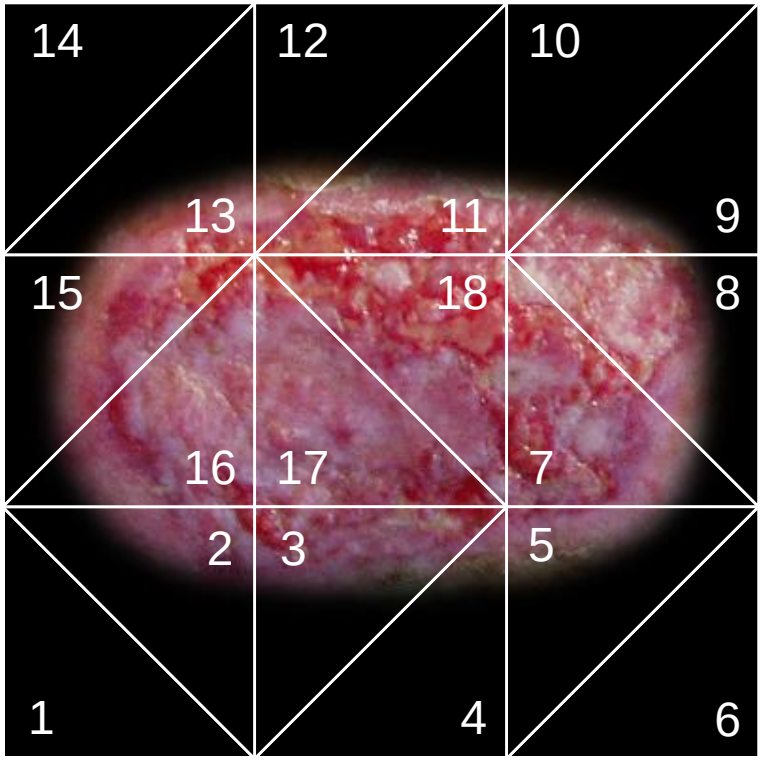
Methodology

- Model Coordinate Mapping
  - Some range of polygons needs to be selected for the space for the wound.
  - At first, algorithm of model coordinate mapping finds a facing of the selected polygon.
  - After that, the algorithm finds sixteen neighbor polygons that share vertices of the selected polygons.



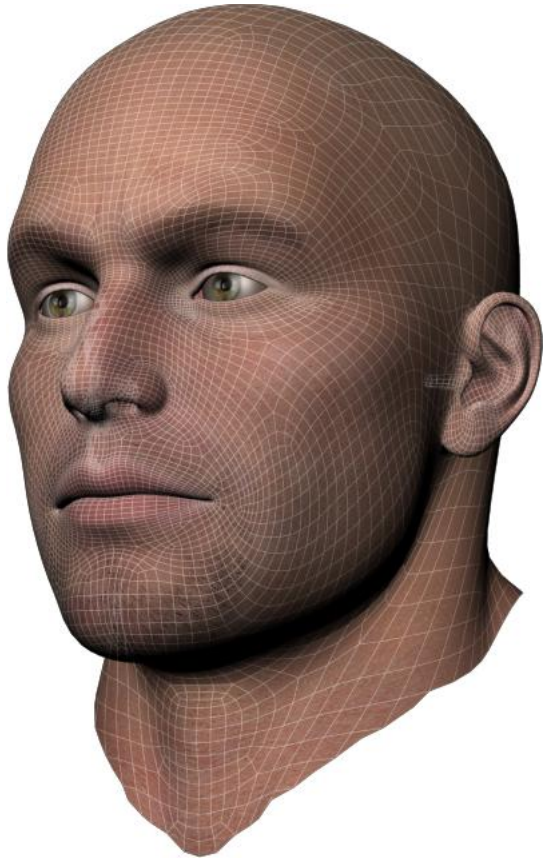
Methodology

- Texture Coordinate Mapping
  - To determine it's UV coordinates of wound texture images, Texture coordinate mapping is required.
  - The eighteen indices are given to all polygons in a counter-clockwise direction.
  - UV coordinates are set up on wound images based on the eighteen indices.



Experimental Results

- 3D Facial Wound Synthesis System
  - A realistic 3d human face was made by using an 3d authoring tool
  - It was converted into an ASCII formatted data for comprehensive manipulations.
  - The model is composed of 24,252 vertices and 47,040 polygons.
  - The resolution of texture image is 4,000 square pixels.



Experimental Results

- 3D Facial Wound Synthesis System
  - To simulate wound synthesis on the face model, we developed a 3d facial wound synthesis system
  - It simulates 3d face model with OpenGL and MFC.
  - The face can be scaled, rotated, translated by using mouse movement so that a user can easily select the position of wounds and check the result of synthesis.

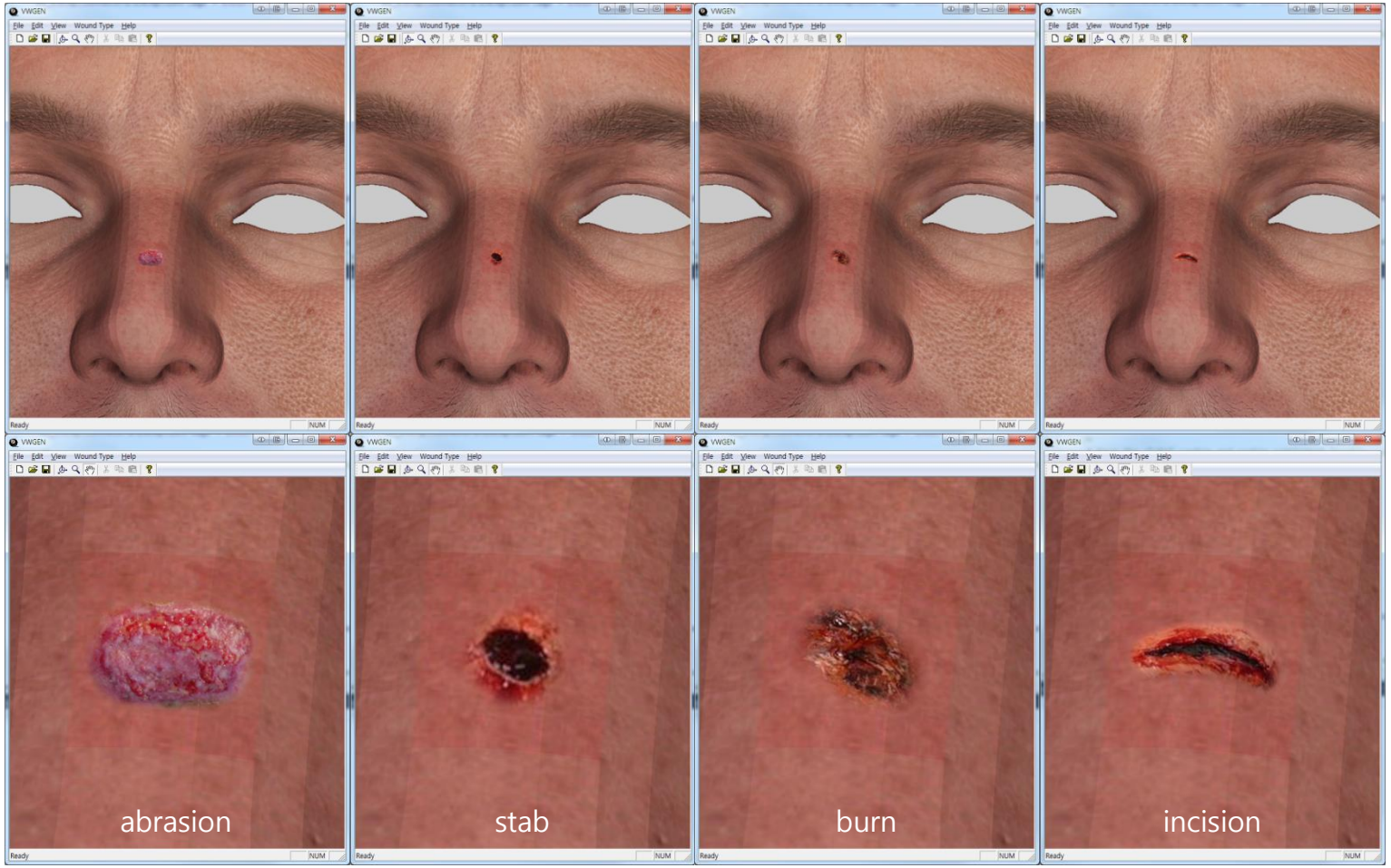
Experimental Results

- Results of Wound Synthesis
  - Using the 3d facial wound synthesis system, we synthesized the four kinds of wounds including abrasion, stab, burn, and incision.

(a) Abrasion (b) Stab (c) Burn (d) Incision

Experimental Results

- Results of Wound Synthesis



Experimental Results

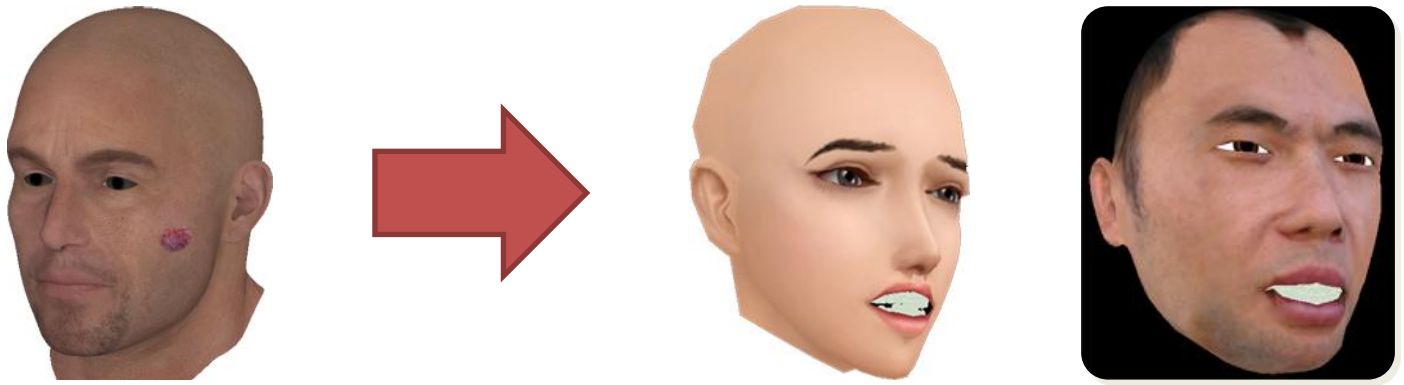
- Results of Wound Synthesis

Conclusion

- Summary
  - We proposed a method of an interactive wound synthesis on 3d human face model.
  - The approach with a user-friendly interactions enabling that a user simply can select the area where wounds need to be appeared is presented.
  - The algorithm automatically figures out 3d coordinates of vertices from pointed 2d window systems based on inverse projection mapping and attaches wounds on the 3d face without any manual work with model coordinate mapping and texture coordinate mapping.
  - To simulate wound synthesis on the face model, we developed a 3d facial wound synthesis system using OpenGL and MFC.
  - The approach of this research can increase reality in movies, games and agents.
  - Besides, it can be used in the fields of virtual surgery, medical training, forensic science, and archeology as a simple method to attach various types of wounds on 3d virtual face.

Conclusion

- Future Works
  - Some wounds are unnatural because their colors do not fit to the skin tone of face model. The method that transforms the wound color tone to be matched one for the face is further needed.
  - The character's facial expressions need to be compatible with the wound such like displaying painful mood. The facial expression that represents painful will make more real status of the character.



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Thank-you!

Acknowledgement

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