Computer facial reconstruction

Slowly turning on a computer screen, a reconstructed face seems eerily lifelike. Forensic scientists and computer programmers cooperate to build these digital recreations of crime victims. To achieve the extraordinary realism, they "wrap" computer tomography (CT) scans and photographs of the living around the skulls of the dead.

To recreate faces from skulls using clay requires great artistic skill. To do the same thing on a computer screen is equally skillful, but in a different way. The programmer or technician works in a more abstract medium, indirectly manipulating data to produce a convincing likeness.

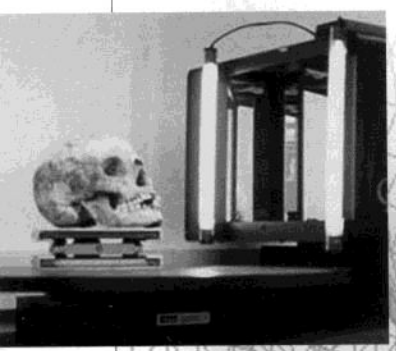
Scanning the skull

Though there is no standard method of reconstruction, the initial data always comes from a 3-D scan of the skull itself. This technique is nondestructive, so the original skull can be used where available, rather than a plaster cast. Typically the skull rotates on a turntable, while a laser scanner illuminates a narrow vertical strip. Mirrors on either side of the turntable reflect images of the illuminated area to sensors. An analysis of the data that they produce allows the controlling program to calculate the distance of each point on the skull from the axis of rotation—and thus create a digital model of the skull that can be freely rotated on screen.

From skull to face

To put flesh on the bones, most computer reconstruction techniques use data captured from computer tomography (CT) scans of living people. Unlike X-rays, which effectively show the shadows cast by bones, CT scans record both hard and

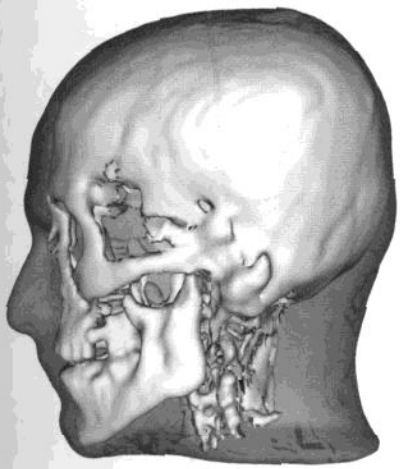
CT SKULL SCAN ▼
Overlapping the CT scan (colored blue) with the victim's skull (colored red) shows how much the CT scan must be "warped" to match the skull exactly.



◀ SPINNING SKULL
The laser scanner is similar to those used to build digital models of faces for plastic surgery, or for burn masks. A powerful computer workstation captures the data.

ADDING LANDMARK PEGS ▲
Software drops the standard facial reconstruction "landmarks" roughly into position on the skull, and their positions are carefully fine-tuned by the operator.

WARPING THE CT SCAN ▲
The process of warping the CT scan, with its corresponding soft tissue, onto the victim's skull may take several attempts. Regions colored purple show where the warped CT scan exactly matches the skull.



TISSUE DEPTH ▲
Once the CT scan has been successfully warped, the CT scan's soft tissue is added. This "skin" (blue) envelops the victim's skull (white) precisely.

RECONSTRUCTED HEAD ▲
At this stage a computer visualization of the head without a realistic skin color or texture resembles a traditionally sculpted reconstruction in blue clay.

soft tissues (both bones and flesh) in three dimensions rather than two. So CT scan data files include both the shape of the skull and the depth of the overlying tissue.

To help choose an appropriate CT scan, forensic anthropologists must use the skull and other remains to estimate the age and race of the subject. Any clues to the subject's build—such as the size of clothing found with a corpse—can help, too, by allowing tissue depth adjustment to account for obesity or emaciation.

By merging the two scans, the CT head is superimposed on to the digital model of the skull (see main image). At this stage, the two skulls are different shapes, so the next step is to "warp" (distort) the CT in a controlled way so that corresponding landmarks on the two skulls match exactly. As the CT skull is stretched and squashed to make it fit, its facial tissue is also distorted, creating a face shape that approximates that of the victim.

Hair and skin

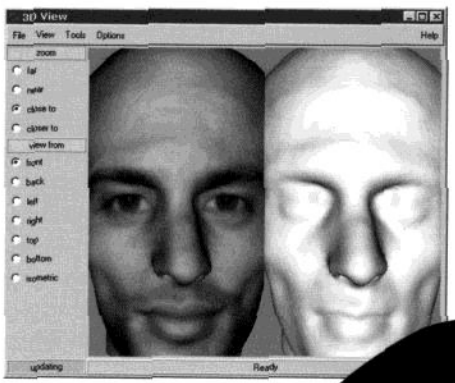
Because CT scans penetrate human tissue, they do not record superficial detail. So at this stage, the reconstruction resembles a plaster cast of the victim's head. To make it look lifelike, textures and colors of human skin, eyes, and hair must be added. To do this, technicians "borrow" the appearance of a living individual and digitally paint it on to the model.

To produce a 3-D rendering, a "color map" of the whole head is needed. This is usually done by photographing a full-face and both profiles of someone whose age, race, and build match the victim. Software merges these three views into a continuous strip that is rendered on to the computer model to complete the reconstruction.

The result can be viewed and rotated on screen, and can be distributed in one of a number of standard viewing formats, such as virtual reality markup language (VRML) or Quicktime VR.

Though computer reconstruction can look more lifelike than a face created in clay, it must be remembered that both methods share the same limitations. In particular, the shapes of the nose, mouth, ears, and eyes are largely guesswork. However, the ability to create views of the victim's face under varying lighting conditions, and from virtually any angle, makes this method of reconstruction especially vivid.

In the future, computer animation techniques may be applied to the facial reconstructions to manipulate the features, raising the possibility that these models could smile, laugh, or talk on screen.



◀ ADDING THE FACE
Photographing a living face in flat lighting provides the skin detail that "wraps" the finished model. The computer creates the realistic highlights and shadows.

FINISHING TOUCHES ▲
Eyes—added from a library—have a lifelike shine. Hair is kept as simple as possible unless there is evidence to suggest how the victim wore it.