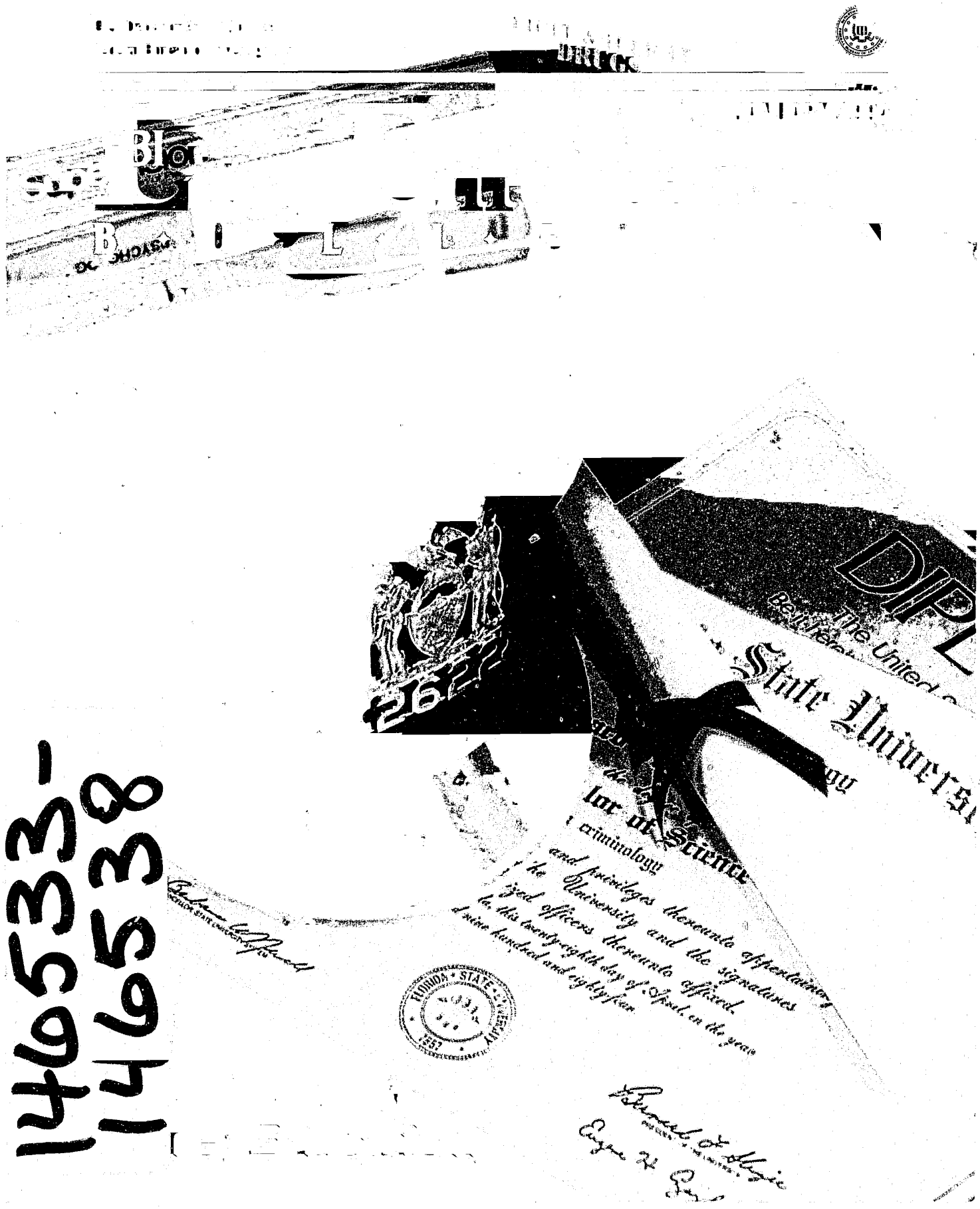

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Features

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Forensic Imaging Comes of Age

By
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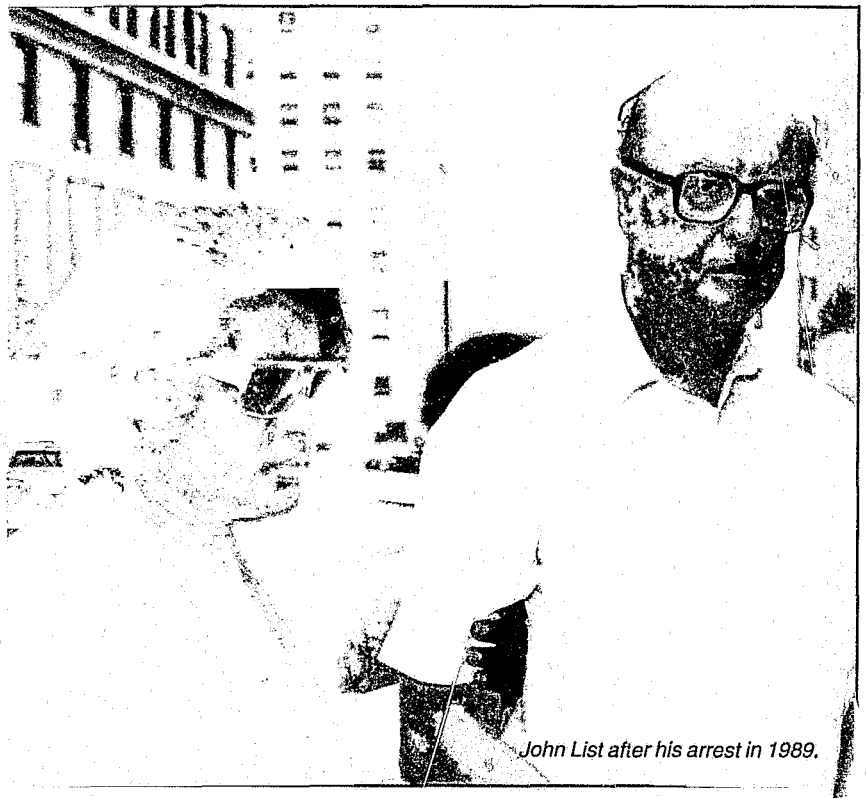
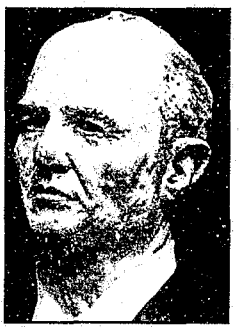


John List after his arrest in 1989.

Photograph of John List taken prior to 1971.

Age-enhanced image of John List prepared in 1987.



Plaster bust based on photographs of John List.

Photo © AP/Wide World Photos

In 1987, the FBI's Newark, New Jersey, field office forwarded a then unusual request for forensic assistance to the Special Projects Section of the FBI Laboratory. Agents asked if it would be possible to produce age-enhanced photographs of a longtime fugitive in order to better represent to the public and to other investigative agencies how the subject might currently appear. The fugitive, John E. List, had eluded detection since murdering his entire family 17 years earlier.

Using newly acquired computer systems, visual information specialists in the FBI Laboratory prepared an age-enhanced image of John List and forwarded it to the field office. The office then publicized the photograph in various national publications. A woman recognized her neighbor as List (who lived under the assumed name Robert P. Clark) from the age-enhanced image that appeared in a supermarket tabloid. The woman dared Clark's wife to confront her husband with the photograph. Apparently, she never did.

Two years later, in 1989, the television show, *America's Most Wanted,* featured a plaster bust prepared by a forensic artist that was based on photographs of List. By this time, List had moved to Midlothian, Virginia, a suburb of Richmond. Convinced that Clark was, in fact, John List, his former neighbor asked her son-in-law to call the FBI and provide investigators with List's new address. When agents confronted the man, he denied he was List. But fingerprints from a gun permit application filed a month before the slayings revealed the truth. List was arrested and

> **"The FBI's imaging program is based on a sophisticated photo compositing and retouching system."**

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returned to New Jersey, where he was convicted of murder and sentenced to life in prison.

The John List case is notable for several reasons, including List's ability to elude detection for 17 years and the impact of mass media on his capture. For the FBI Laboratory, the List case also signaled a new age in computer-assisted forensic imaging.

BACKGROUND

Traditionally, forensic artists assisted investigators by producing drawings and airbrushed photographs based on witness accounts or photographs. Over the years, forensic artists produced many such images, which assisted in solving numerous cases. However, advances in computer technology now allow these same artists to create or alter images much faster, more accurately, and with many more options than ever before.

In 1986, the FBI purchased the computer system used for the age-enhancement of John List. Composed primarily of off-the-shelf hardware and software, the system allows operators to alter photographs for investigative purposes by projecting the likeness of individuals as they might currently appear. By combining the sophistication of the computer system with the forensic art skills of the operator, age-enhancement and other imaging can be achieved with a high degree of accuracy.

The programmer who developed the system used by the FBI worked closely with Laboratory personnel in making necessary modifications to enhance the computer's capabilities. The user-friendly format allows operators with limited computer training to make full use of the system. As always, the most critical element is the forensic art skills of the operators.

COMPUTER-ASSISTED FORENSIC IMAGING

The FBI's imaging program is based on a sophisticated photo compositing and retouching system. The system produces age-enhanced photographs, merged images (i.e., a human skull combined with antemortem photographs), and reconstructed facial images based solely on the skeletal remains. The forensic artist can also create detailed composite sketches on the system and use the system to perform other retouching functions.

In order to produce a desired image, forensic artists must generate several preliminary images. These initial and intermediate images, as well as the final product, are collected together in a folder referred to as a "film."

A film consists of several images, or "frames," in sequence. Each frame corresponds to one of the images used to produce the final product. To ease handling, the artist binds the frames together in a single film. This also ensures that all materials necessary to produce the final image can be found in a single place.

AGE ENHANCEMENT

The age-enhancement process begins by entering the images that will be used in an "update" into the computer system. Forensic artists enter these images into the system in several different ways.

In the most common method, the forensic artist uses the video camera to "grab" or digitize photographs into the system. This is accomplished by placing a photograph on a copy stand under an activated video camera to produce an image on the display monitor. When the photograph has been properly framed, the camera focused, and the lights adjusted, the image is

"grabbed." The computer then converts the image into digital form and stores it in its memory. The forensic artist then repeats the image entry process for each reference image used in the aging process. When all of the photographs have been entered into the system, the forensic artist begins creating the aged image.

The computer displays available commands in a collection of pop-up menus driven by a fixed menu selection that runs across the bottom of the screen. The operator selects a category by pointing to it with a pen-shaped stylus. Once the operator makes a selection, the list of commands in that category appears in a pop-up menu. The operator alters the image by selecting different commands from the various menus and then drawing on the image using the stylus. Mistakes can be corrected through a variety of commands.

Child Aging

When "aging" childhood photographs, forensic artists can develop highly accurate and detailed enhancements by studying photographs of the subjects' family members to gauge accurate facial growth patterns. Since the introduction of the computer-assisted system, the FBI Laboratory has assisted in locating several missing persons, based solely or in part, on this investigative technique.

To update a child's appearance, the forensic artist enters photos of the child, as well as one or both parents (or siblings who resemble the child) into the computer. The operator then creates grids for each image that "describe" the location of the facial features in that image. One or more of the missing child's photographs are "warped" or realigned to bring the features of that image into alignment with those of another.

After this process, the images can be composited (or combined). The result represents the aged image because warping simulates the

System Configuration

For any forensic imaging function, the software requires the following basic hardware configuration: A standard personal computer (PC) terminal containing at least 4 megabytes of memory and a minimum 100 megabyte hard disk, a digitizing tablet, color video display monitor, and a video camera with lights (preferably mounted on a stand). A "grabber/buffer" board should be installed in the main terminal. If necessary, custom hardware configurations can also be supported.

Connected to the PC, the digitizing tablet is used as a pointing device. The computer detects the position of the stylus and draws crosshairs on the video screen to show its current location. The operator draws with the stylus, much as an artist might sketch with a pencil or pen.

The color video monitor displays the images and the menus that control the program. A color monitor is preferable, even though the images are black and white (also called gray-scale). The color monitor yields far greater resolution than an ordinary television screen.

A video camera captures the images that are used to produce an altered image. The camera is mounted on a copy stand so that the source photos used to produce updates can be easily scanned. The artist converts the image produced by the camera into digital information, which is then stored in the computer.

growth of the child's face. The percentages of the images to be composited can also be adjusted to emphasize one image or another. By adjusting these percentages, as well as the degree of warping, the artist determines the "age" of the resulting image. Retouching capabilities allow for various hairstyles or the removal of blemishes.

When deciding on what photographs to combine with the child's image, investigators should look for similarity of features in the photographs of the relatives taken at approximately the same age as the missing child. However, in photographs to be used in the update, relatives must be as close as possible to the age the child would be currently. The position of the heads in the photographs of the child and the relatives must match closely. Facial expressions should also match. Ideally, photographs should be evenly lit and of high quality.

Adult Aging

The aging of an adult subject works in a very similar manner to the updating process for a child. The primary difference lies in the use of an age template that is combined with the image to be aged. The artist modifies the template to fit the features of the image.

Because cranial growth is complete in adults, the artist gives special attention to preparing an accurate depiction of the skin surface, adding necessary creases around the eyes, forehead, and other appropriate areas. Indications of hair loss in earlier photos or information from witnesses may lead the artist to remove hair or make other changes, such as adding a beard or a scar or adjusting the weight of the face.

As with the updating of a child's image, any photographs that are to be combined must be in similar orientations—preferably head-on shots. Slight deviations from this full-face angle can be compensated for during the warping process, but some distortion may result. If the deviation is too great, another image should be used.

Child Aging

Photograph of a child at age 3.

Age-enhanced image of the same child as a teenager.

SUPERIMPOSITION

Forensic laboratories often receive requests for assistance in cases that require the comparison of an antemortem photograph with a recovered cranium and mandible (jaw bone). The computer-assisted system for photographic superimposition offers a highly effective method to demonstrate consistency (or inconsistency) between skeletal features and facial photographs.

First, the antemortem photograph is scanned with a video camera and then digitized and stored in the computer. The artist traces key anatomical "landmarks" directly onto a plastic overlay on the monitor. The image of the photograph is removed from the monitor, and the image of the cranium and articulated mandible is oriented manually until the position approximates that of the individual in the photograph.

The image of the photograph and the image of the cranium/mandible are then merged or superimposed to allow detailed comparison. The artist stores the superimposed images and prints them on high-resolution printers. Accurate comparison requires the combined efforts of a skilled forensic artist and an experienced forensic anthropologist.

FACIAL REPRODUCTIONS

When investigators find human skeletal remains with few clues as to their identities, forensic scientists, artists, and anthropologists

often attempt to re-create the images of the individuals from the skeletal remains. In the past, two-dimensional drawings and three-dimensional reproductions of the remains—with clay added directly to the cranium to simulate anatomical features—produced helpful leads for investigators.

In recent years, facial reproduction has become an increasingly important tool within forensic anthropology to identify missing persons. While the technique is of little value for purposes of positive identification, it can be extremely useful in presenting an image to the public.

In computer-assisted facial reproduction, the cranium and articulated mandible are positioned in what is called the Frankfort horizontal plane (a scientific articulation of the cranium and mandible for photographing the cranium) and scanned with the camera. The artist selects features and adds them to the captured cranial image. The artist and the anthropologist then modify the features until a lifelike image conforming to the proportions of the underlying cranium is produced. In the FBI Laboratory, facial components are selected from a large database of handdrawings that depict wide variations in facial features, complexions, and hairstyles.

COMPOSITE SKETCHES

For many years, investigators have sought the assistance of forensic artists in yet another area of forensic imaging—composite sketching. FBI use of such drawings dates back to 1920; use in other agencies dates back even further. Television programs often depict a police composite artist at the bedside of a victim, quickly sketching a portrait of an unknown assailant. While real-world forensic artists often produce portrait-style drawings, these images generally require hours of interviewing, drawing, and revision.

The FBI has converted its book of photographs used for interviewing witnesses for composites into handdrawn images to use as a database on a computer that will automatically generate images similar to those that are handdrawn. Once the witness selects features from the catalog, the composite image appears on the computer screen in just a few minutes.

> ***"...computer-assisted programs provide greatly improved capabilities at a fraction of the time similar imaging once took."***

Often, an artist is not even necessary. With practice, investigators can place the features on the screen and modify the image as the witness instructs. The system can be loaded into a laptop computer to further speed up the process by taking it directly to a crime scene. It can also be accessed via a modem hookup or put online, with an artist in another city available to prepare the composite while a witness views and suggests changes.

PUBLICIZING IMAGES

Investigators should remember that even the most accurate forensic images are of little value if potential witnesses never see them. This is especially true of age-enhanced photographs.

After sending the photographs to Federal, State, and local law enforcement agencies, investigators should consider additional ways to publicize the image. The more people who see the image, the better.

Generally, programs that spotlight criminals and missing persons on national or local television and/or in newspapers yield the best results. One investigator from Oakland, California, reached out across the United States and Canada with age-enhanced images of two missing brothers. After exhausting every lead, the investigator turned to the television program *Unsolved Mysteries*.

On the evening of the broadcast, hundreds of calls poured in from the Albuquerque, New Mexico, area. Authorities located the children in a trailer on the outskirts of town, where they lived with their mother and her new husband—a known drug dealer. The boys were returned to their father, who had not seen them in several years. Although the aged images of the boys were very accurate, the relentless determination of the investigator and the assistance of the public ultimately solved the case.

Other methods can be used to publicize an image. Most States have at least one agency dedicated to the location of missing children that assists investigators in publicizing such cases. Wanted and missing

Guidelines for Submitting Evidence

The FBI Laboratory accepts a limited number of forensic imaging requests each year from State and local law enforcement agencies. Before forwarding skeletal facial remains to the FBI Laboratory for reconstruction or comparison to antemortem photographs, the remains should be completely defleshed and cleaned, preferably by a medical examiner or anthropologist. The medical examiner's report and any hairs, fibers, and photographs taken at the discovery site or medical examiner's office, as well as any other pertinent evidence, should accompany the submission.

In cases where investigators suspect that they may know the identity of the subject, recent antemortem photographs, as well as photographs of the possible subject smiling (for dental comparisons), should be included.

Agencies should package materials carefully to avoid damage. All evidence and bones should be packaged separately and then placed in a sturdy box. Soft bubble plastic or comparable materials should be used to cushion the evidence.

Before submitting evidence, however, investigators should first call the FBI Hairs and Fibers Unit to discuss the case. An explanatory letter with relevant background information should accompany the submission. Requests for superimpositions and facial reproductions should be sent to:

Federal Bureau of Investigation
9th and Pennsylvania Avenue, NW
Washington, DC 20535
Attention: Laboratory Division
Hairs and Fibers Unit

Requests concerning composite art, age-progression, or other photographic retouch should be sent to the attention of the Laboratory's Special Projects Section.

person posters often provide a worthwhile medium. Many printing companies produce posters and flyers concerning missing children at a reduced rate or at no charge. Companies offering coupon advertisements featuring missing children have also proven effective.

THE FUTURE

New computer-assisted forensic imaging technology looms just on the horizon. For example, the introduction of three-dimensional digital skull imaging will give forensic artists the ability to rotate facial images on screen, allowing for more movement of facial expression and the addition of detailed facial features to the image.

New technology will also enhance superimposition capabilities. For example, on-screen rotation of cranial images will allow forensic artists to align antemortem photographs more accurately.

These and other improvements will enable forensic artists to provide new levels of assistance to investigators. Further computerization of the forensic imaging process promises to provide law enforcement with enhanced facial identification capabilities as the 21st century approaches.

CONCLUSION

For decades, forensic imaging has benefited law enforcement. Now, computer-assisted programs provide greatly improved capabilities at a fraction of the time similar imaging once took. When combined with the communicative power of modern mass media, the impact of forensic imaging can produce impressive results, even for cases once deemed hopeless. ✦