Measuring facial strains for the cosmetic industry

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A unique 3D image correlation technique measures skin displacements, facial strains, and wrinkle formation.

Human skin is sensitive to a range of factors, such as UV rays and stress, that cause the form of a face to change with age. Everyday motions, such as blinking, cause wrinkles to appear in areas that are subjected to repeated deformation (e.g., around the corners of the eyes and the middle of the forehead). The strains associated with these motions are thought to be related to the generation of wrinkles, but a definitive relationship has not yet been established.

If strains are indeed related to wrinkle formation, and that relation can be understood, it should be possible to reduce wrinkles by controlling the strains with effective cosmetic products. To reduce the formation of wrinkles with aging, skin is usually protected by cosmetics against desiccation and UV radiation. Some studies have focused on the measurement of strains on the face (or skin) to determine the mechanical properties of skin. Until now, however, there have been no investigations of the relationship between facial strains and wrinkle formation.

For our study we used a stereo-vision technique that is based on digital image correlation. This is the most suitable for quantifying strains on facial skin because it can measure large forces on a 3D surface. With this technique, temporal variation of skin motion is monitored from the consecutive images that are obtained using a pair of high-speed cameras. The strains on the skin are calculated by differentiating the measured displacements on the surface.

We measured facial surface displacements during various common motions (e.g., blinking) using two high-speed cameras (with 1024 × 992 pixel × 8 bit resolution) at a frame rate of 100 frames per second. First, we performed a calibration to determine the intrinsic and extrinsic parameters of the cameras. We then determined the corresponding points on the facial surface in the pair of stereo images using our custom-made digital image correlation technique. The 3D coordinates of the surface before, and after, deformation are thus calculated and the displacements are found by subtracting the coordinates prior to deformation from those after.

Figure 1 shows an example image obtained with our stereo technique. Different parts of the face—i.e., the eyes, nose, and cheeks—can easily be recognized. The shape that results from using this technique is used to define reference coordinates for measuring facial displacements and strains. Figure 2 shows strains and motions around a right eye during blinking. Contour maps of the maximum and minimum principal strains, as well as the principal direction of motion at the instant of eye closing, are shown. High strains are observed both in the eyelid, just above the eye—see Figure 2(a)—and around the edge of the eye: see Figure 2(b).

We carried out facial strain analyses on four female subjects of different ages (one in her 20s, two in their 40s, and one in her 60s) while they experienced various common movements. We made replicas of their skin surfaces to study the formation of facial wrinkles. In addition, we measured the moisture content, flexibility, and elasticity of their skin to investigate the condition...
Figure 2. Strain distributions around a right eye during blinking, at the instant of eye closure. (a) Maximum principal strain. (b) Minimum principal strain. (c) Principal direction of motion.

of the surface. The results of our tests show that wrinkle grooves form in directions that correlate with the direction of maximum or minimum principal strains. It is therefore necessary to employ different methods and products to reduce wrinkle formation around different points of the eye. The skin of our younger subjects had higher moisture, flexibility, and elasticity, but we did not observe a relationship between these parameters and the magnitude of the strains we measured.

In summary, a new digital image correlation technique can be used to investigate the relationship between wrinkle formation over time and the facial strains involved in common movements.

We are continuing to study the effect of the skin’s moisture retention on strains around eyes.

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