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FACE FACTS

Exploring facial features with the help of mathematics

Researchers in the Institute of Neuroscience and Psychology at the University of Glasgow are investigating the information that our faces show to each other. The researchers are exploring how the shape of features, such as eyes and mouth, as well as their relative positioning within a face affects the perception of a person. We unconsciously use such visual cues to recognise family as well as determine expectations of a person's character.

The researchers have developed tools to *transform* faces while retaining many of their distinguishing characteristics. For example, they can transform a male face into a female face while keeping the features that define individual identity – if the male face has large eyes or was particularly masculine *for a male face*, then the female transform will also have large eyes and appear masculine *for a female*. They do this with the help of vectors.

Vectors are mathematical objects that describe both length and direction. They can be used, for example, to measure in a photo how *far* the right eye is from the nose and what *direction* it is in. We can add and subtract vectors, and we can make them longer or shorter. By outlining certain features on a photograph of a face we can measure the vectors that describe the position of these features within the face. The measurements for many different faces can be combined to produce an average face, called a *prototype*.

To find the prototype for a collection of faces the average location of each feature is found by taking the average of the vectors. Just like numbers, we can add up vectors and then divide by how many there are. The faces are then digitally altered so that all the features overlap perfectly and the images are blended together. The researchers have produced prototypes for different ages, genders and ethnicities.

Using prototypes it is possible to transform faces, for example by changing their gender or age, while maintaining other distinguishing features. To change from male to female, for example, you must keep other variables, such as age and ethnicity constant, as these will also affect the position of features.

The difference in the position of the features of a particular male face from the average position for the prototypical male can be measured by subtracting the prototype's vectors from the example's vectors. This tells us how the particular face differs from the average face. These differences can then be applied to the prototypical female face. Computer graphics are then used to distort the original face into this configuration.

www.facefacts.scot

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