Stepping Beyond the Bounds of Assistive Technology with the Makeup Assist App

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Abstract

Makeup Assist is an iOS app that improves the experience of applying makeup for individuals who are blind or visually impaired. Most efforts in developing assistive technology have concentrated on making necessary tasks more self-reliant. This app strives to create more ways through which blind and visually impaired people can freely express themselves and experience independence beyond just basic tasks. With Apple's Face Tracking technologies, voice overs capabilities, and Firebase's cloud database, the Makeup Assist app provides real-time assistance and feedback to achieve just that.

1. Introduction

Modern assistive technology primarily consists of solutions to exist autonomously (and improvements upon those solutions), such as text-to-speech readers and navigation. While these basic necessities are crucial, not much else is accommodated beyond them. Options for personal expression, enjoyment, and fulfillment are limited to what can be easily accommodated for. Many hobbies, forms of entertainment, and aspects of popular culture are not readily available for people who are blind or visually impaired to engage in.

Makeup is one such area that has always been inaccessible for those with visual impairments, due to how much it relies on visual aspects. Besides offering a route of artistic and self-expression, makeup is also a substantial portion of modern culture; trends, communities, and identities are formed around it. Furthermore, it is important to the professional world, being related to "upward mobility" within the workplace and serving as a "proxy for professionalism" (Li et al., 2022). This is because appearance plays a huge role in sighted people's perceptions of others; "people with more attractive faces are judged more positively," and consequently receive more "preferential treatment" (Zebrowitz & Montepare, 2008). Overall, makeup is significant as it can directly impact all facets of life.

Yet, for blind individuals, there are a notable amount of obstacles within the experience of applying makeup. Through analyzing 145 Youtube makeup tutorials and interviewing 12 individuals, Li et al. (2022) highlights the main challenges. First, learning makeup with a video tutorial is difficult because commentaries often rely on unhelpful demonstrative pronouns. For example, the video creator might say something like "I'm using 'this' blue eyeshadow and applying it 'right here'." Without being able to see the eyeshadow palette or your own face, it is impossible to know where 'this' and 'here' entails. Another prominent issue is distinguishing between makeup products. Especially within the same "lines" of makeup, products are often designed with very similar packaging that makes distinguishing between them a challenge. And the ability to tell colors apart is not even an option.

Various companies have attempted to combat some of these problems. A few makeup brands like L'Occitane and Proctor & Gamble create products with braille labels or tactile markers. Platforms like BeMyEyes rely on sighted volunteers to guide blind users through video calls. Apps such as Color Blind Pal help with basic color distinctions (Li et al., 2022). But despite these accommodations, makeup artists who are blind or visually impaired have a much higher learning curve overall. And even if they practice enough to become independent on the makeup application process, there is always the requirement of having someone double check over the finished look for any accidents. It's hard to make the makeup process completely autonomous, and this requirement is a direct reason why. Among all the assistive technologies developed for makeup applications, there is nothing that allows for people to independently check over their makeup.

The Makeup Assist app is significant because it does just that. It gets two sets of images - one set representing the user's face before applying makeup and the other representing their face with makeup on. Then, it uses color difference algorithms on each pair of corresponding images to determine where makeup was applied. This will allow the user to catch accidents; for example, if they have lipstick on their cheek.

2. Methodology

A. Codesigners

This study was conducted with the help of 7 codesigners, who are women around the US and the UK who are blind and either have experience with makeup or are interested in learning it. Initial interviews with them highlighted their struggles with makeup, and brought the focus to one pain point. These codesigners also provided live feedback for the various iterations of the app, helping to improve the user experience.

B. App Foundations

The main focus of the Makeup Assist app is color comparisons between the pixels of two images. However, before this algorithm could be developed or tested, a lot of baseline infrastructure needed to be in place.

First, the app needed to help the user center their face within the camera screen. If the camera couldn't detect a face within the screen, the images meant for the color comparison algorithms would not be rendered, and the entire algorithm wouldn't work properly. The implementation of this feature was inspired heavily by the selfie helper voiceovers for the iPhone Camera app. This foundational piece relied on analyzing Apple's AR Face Geometry data. Included within Apple's ARKit library is a robust face-tracking technology for iPhones with TrueDepth cameras. Using this library, the app generated a mesh representing the topology of the user's face. The transform matrix associated with this mesh could be analyzed to determine the position, orientation, and rotation of the user's head in relation to the phone camera. Voiceovers were used to inform the user of their face position and orientation within the bounds of the screen.

The second required foundation block of the app was implementing UV unwrapping. This process took the 3D information of the face - including the topology, positioning of facial features, and colors - and distorted it into a 2D image. This image is referred to as a "UV texture" as it is generated in the UV plane. The face topology mesh consists partially of vertices where the mesh lines meet, and each vertex was mapped to a 2D coordinate. This is similar to how a map is the 2D representation of a globe - the map carries the same information as the globe does, but is distorted quite a bit because it is flat and rectangular. Code from Matt Bierner's project "HeadShot" was used to create this unwrapping process.

Figure 1: a UV-unwrapped image of a person's face

The third foundation piece was the ability to collect these UV textures automatically when the face met specific conditions. One UV texture was not enough to represent the entire face, because the entire face was not visible. Therefore, multiple textures from different angles of the face were necessary. Four textures were captured at the following angles: slightly rotated left/slightly rotated right (approximately 10º each direction), rotated left/rotated right (approximately 45º each direction). One set of these four textures was captured before the user applied any makeup, and another set was captured after the user had makeup on their face. With these two sets of images, there were four corresponding pairs of identical face rotations to compare against each other.

C. User Experience

After these three foundation pieces were implemented into the app, the study's codesigners tried it out and provided feedback. Issues with user experience arose, in that there were not a lot of instructional voiceovers to provide context for what was occurring during each app stage. Additionally, voiceovers were needed when buttons appeared on the screen, to describe where the button was located and what the purpose of it was. These issues were fixed before beginning to work on the image comparison algorithms.

The app has a linear flow. At the very beginning, a paragraph introducing the app and how it works is read to the user. Afterwards, the user is guided to center their face within the screen. Once they have successfully centered it, they are guided to rotate their head around to gather the UV textures, representing the face without makeup. Then, the user is able to apply their makeup. After the makeup is applied, the user clicks a button to gather the second set of UV textures. Then, the app will read out where the image comparison algorithm detects makeup on the face.

Every 10 seconds, analytics about the user's face transform matrices and button clicks are sent to the backend cloud storage. Both sets of UV textures are saved locally on the device, as well as in the backend storage to be used in improving the image comparison algorithm.

D. Image Pixel Comparison

The general idea for this comparison algorithm is that there are two sets of images of the face before and after makeup is applied. A total of four pairs of images (one from each set with the face at the same angle) can be taken and compared pixel-by-pixel. Before the comparison occurs, however, there is likely to be some image alignment needed, and some calibration of lighting conditions between the two photos. This can be done using Computer Vision algorithms.

3. Results and Discussion

Through the first round of codesigner interviews, it was observed that much of their makeup struggles matched what was highlighted in existing literature. However, the main pain point across most responses was that they had to rely on others to help check over their final makeup look to ensure no accidents had occurred. This was different from existing literature, and greatly helped to narrow the scope of this project.

Currently, attempts to run post-processing comparisons through OpenCV reveal some issues with how the UV textures are captured.

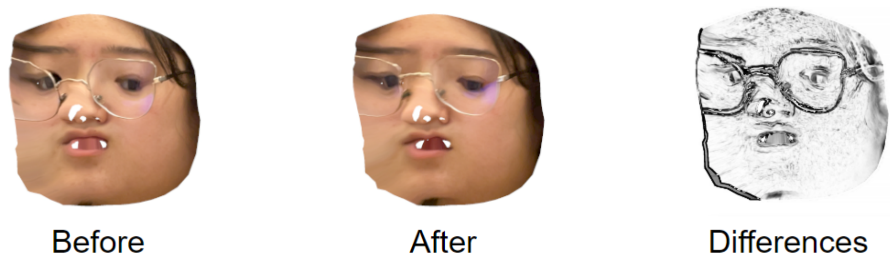

Figure 2: post-processing comparison of two somewhat imprecise images

To start off, while the two images on the left of Figure 2 seem similar, they are actually at slightly different angles. This causes slight discrepancies that turn into lots of noise when comparing the images pixel-by-pixel, as seen in the right image of Figure 2. While this issue could be mostly solved through image alignment algorithms, it could also be easily solved through strengthening the way the UV textures are captured. Within the app, there is a specified range of what is considered "slightly rotated right/left" and "rotated right/left". The app will capture a texture when it is in this general range, which means there is a variety of angles that the face can be captured at. This is likely the reason for the discrepancies visualized in Figure 2, so ensuring the face is at the exact same orientation and rotation each time should eliminate the problem entirely.

Two more issues were revealed through examining the quality of all the UV textures stored in the backend. First, obstacles in the face often get captured as part of the face. Hair, fingers, and more can still cause the face to be detected (and therefore, images to be captured), but will cause problems in comparing images. There is currently no way of specifically checking each image for such obstacles. Implementing a form of obstacle recognition will help improve the overall effectiveness of the image comparisons. The second problem is lighting. If the position of the lighting source changes dramatically, new shadows can form that will throw off the pixel color comparisons. Furthermore, lighting strength can change in the time between when the two sets of images are captured. Thus, there needs to be a way to calibrate the lighting between the two before comparing pixels of the image.

4. Conclusion

Overall, making makeup more feasible for the blind and visually impaired community is useful and significant in the world of assistive technology. Not only does it open up the vast world of makeup, but it also is a step beyond making accessible technology purely for basic necessities.

Based on the results of this study, further research and improvements are needed for the face comparison algorithm. Aspects like consistent lighting and obstacle detection need to be enforced to create as similar conditions as possible between two images. However, a balance will need to be found to ensure user-friendliness.

Additionally, more ways to compare faces should be looked into. On the image capturing side, perhaps UV textures are not the best way to analyze images. Testing should be done for other methods, such as direct images of the face as seen by the camera, to compare the efficacy. On the comparison algorithm side, using pixel-by-pixel comparisons may be too nitpicky and might cause lots of noise for slight color differences. Other comparison methods should be looked into as well to find the most effective one.

Once the improvements upon the face comparisons are successful, additional functionality to the app should be implemented. The plan is to tackle more pain points that codesigners have expressed in interviews. The end goal of the Makeup Assist app is to make the makeup experience completely independent and approachable to those who are blind or visually impaired. The app will eventually be capable of supporting the entire makeup process, from identifying products to distinguishing between colors to checking over final makeup looks for accidents.

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