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**Identifying the location of a 5th metatarsal “Jones” fracture from an image to assist with at-home therapy.**

RUN “boundaries.m”

The goal of my project was to automate one of my daily tasks. Applying the bone stimulator to my foot was at first intimidating because positioning is so crucial – only after doing it many times does it become easy to position the device correctly. A vision-based approach to this problem would make it much easier for those unacquainted with foot anatomy.

The first thing I did was to take an image of my foot that would be easy to segment or bound. To do this, I put a black cloth on the floor below my foot, placed a lamp directly above the foot, and took the picture from about 6 inches directly above the foot. This made my foot appear bright against a noise-free background so only 1 clear object existed in frame. After that, I cropped some of the bottom of the image where my leg was visible, leaving only the portion from my ankle to my toes (this will be important later). I also downsized the image for easier processing.

Next, I converted the image to black and white and found the northernmost white point in the image, which is the top of my big toe (if the background is noisy it can catch an erroneous white point. A Gaussian filter might help.). I then used the boundary drawing tools to draw a boundary around the foot starting at that northern point. From there, I tried to identify the part of the foot that was sitting on the bottom of the image (since I cropped to only in front of my ankle, the bottom of the picture corresponds to the end of the metatarsals, a bone of interest). Once I had this line across the bottom of the metatarsals, I pruned all the boundary points that lie either outside the metatarsals or below halfway in the picture. Since the toes exist in the top half of the frame, it gave me a line around my toes.

This toe boundary is where most of the analysis begins. I parsed the toe boundary along all 5 toes looking for the southernmost point, which corresponds to the bottom of the gap between the two outermost toes. Using the coordinates of this first gap, I sequentially found the next three gaps between toes, relying on the fact that these gaps will be local minima that have similar y-values to the gap that came before. After finding the four gaps between toes, I could segment each toe away from each other, splitting the toe boundary at the coordinates for each gap. From here, I could find the northernmost point of each toe, which corresponds to the top of the toe.

With the coordinates for the top of each toe and the gaps between them, I found where each toe meets the foot (the midpoint between the gaps of the toes). Now that I had the top and bottom coordinates of the phalanges, I could draw them in in red on top of the original image. Going back to the bottom border, I assumed that the outside metatarsal lays on the western edge of the bottom border and the inside metatarsal lays on the eastern edge. I then calculated where the other 3 metatarsals would lay, evenly spacing them between the outside ones. With this information plus the coordinates of the bottoms of the phalanges (i.e. the tops of the metatarsals), I could draw in the metatarsals in white.

Finally, I estimated the position of the Jone’s fracture, knowing that it normally occurs about 4/9 of the way up the shaft of the fifth (outside) metatarsal. Using trigonometry, I found the point between the bottom and top of the metatarsal that is 4/9 of the way from the bottom and drew a yellow circle around it. The final image shows the bone structure of the five phalanges and metatarsals and circles the area of interest (the Jone’s fracture), showing the patient where to put the round ultrasound head of their bone stimulator.