Turtle Identification

Through Template Creation & Matching

Kirsten Dohmeier, Michel van Eekelen
(EENG Students at the University of Victoria, BC, Canada)

INTRODUCTION

The purpose of this project is to use computer vision techniques to sort a picture database of Western painted turtles. A database of images was provided by Dr. Albu. It contained between two and five images of each turtle. By comparing the unique patterns on each turtle, individual turtles can be identified without need for human input. A practical application of this project is to provide a non –intrusive means of animal tracking. Many cameras come equipped with the ability to tag a GPS location to pictures, which could be used to track the movements of a individual turtles. A picture taken of a turtle can be compared to a database of identified turtles, and if it has been cataloged before, its location information can be updated. Otherwise, the image of the turtle may be entered into the database as one that has not been cataloged before. Fig. 1 is an example of an image of a Western painted turtle that needs to be cataloged.

Figure 1 - Western Painted Turtle

RELATED WORK

The paper Automatic track recognition of footprints for identifying cryptic species (Russell et al. 2009) was used to establish a methodology for template matching. It describes the feasibility of automatic recognition of tracks of morphologically similar subspecies of rats. The two main procedures that this paper describes are also used in this project: template extraction and template comparison.

A. Template Extraction

The paper describes identifying unique regions of the footprints of the tracked animals (heels and toes) and representing their locations with ellipses. In the paper, the local tolerance for adaptive binarization was manually adjusted as multiple footprints were gathered on the same image and the clarity of all the footprints was not uniform. Firstly, the centre pad of the footprint was located based on area constraints. Ellipses were fit to the centre pad and toes, and the prints catalogued based on the Euclidean distance between toes and the centre pad as well as the relative angles of toes.

B. Template Comparison

Using a continuous Gauss function, the distances and angles between toes and heels were compared to those in the template database and given similarity value.

PROJECT APPROACH

The project is broken up into three main components: preprocessing, template creation, and template matching. There was a great deal of variation among the images in the database used. Certain obstacles addressed in this project include the relative size and location of turtles in the images, foreign foreground objects such as measuring tapes and heavily textured backgrounds. It was necessary to account for all of these variances in precessing the images. Despite the large variance from image to image, it was possible to take advantage of a common trend: the orientation of the turtles in all of the images was the same. The basis for comparing the images of turtles to one another was the horizontal centre line common to all of the images.

C. Preprocessing

- Resize images
- Enhance contrast of the red component
- Use Otsu's method to get the global threshold level
- Convert the image to binary format
- Pad the image borders
- Perform Gaussian smoothing on the red component of the image
- Define points of an ellipse to the image for active contouring
- Apply active contouring to image
- Remove background from binary image

D. Template Creation

- Erosion using a horizontal line structuring element
- Remove the vertical components

Remove components with small major axes
Select component with the greatest eccentricity as the centre line of the turtle
Rotate and move the binary image based on centroid and angle of centre line component
Save the modified image in the template folder

E. Image Comparison

Remove all but the connected component at the centre of the image
Morphological opening with a disk structuring element
Remove components not crossing the center component
Morphological closing with a horizontal line
Fit an ellipse to center component based on the centroid and major axis length of the centre line component
Use the ellipse as a mask on the template and remove the background
Repeat above steps for each image being compared
Find correlation coefficient between the image in question and the database
Save the top 3 matches based on the highest correlation coefficient

Experimental Results

The database of images of turtles that was provided by Dr. Albu originally contained 69 images of turtles. A naming convention was implemented to easily identify whether the algorithm had correctly identified the turtle. The number associated with each image identifies the turtle, and the letter distinguishes the individual images.

After resizing and enhancing the contrast of the red component of the images, Otsu's method was applied to obtain a global threshold level. As there was only a single turtle in each image, we were able to apply global thresholding unlike in the referenced paper where footprints were of varying intensity and required manual adjusting of the local tolerance for each image.

In order to deal with artifacts such as fingers, tape measures and wood with horizontal grain in the images, preprocessing with active contouring was applied to the images in order to segment the turtle from the busying background. It was not necessary that the contour conform perfectly to the turtle's shell, but rather that it remove background disturbances while keeping the centre line of the turtle.

As in some images, the turtle's shells were slightly outside the limit of the image border, each image was padded prior to processing allowing for the active contour spline to be defined outside of the original image borders.

The active contouring algorithm by R. Kumar was applied using 18 points around the turtle as shown in Fig. 2. These were then interpolated, and parameters determined to successfully conform to the turtles.

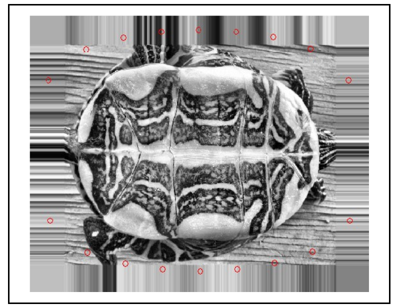


Figure 2 - Ellipse Starting Points

The binary version of the image was then obtained, and the background was removed based on the location of contour at its lowest energy state as seen in Fig. 3.

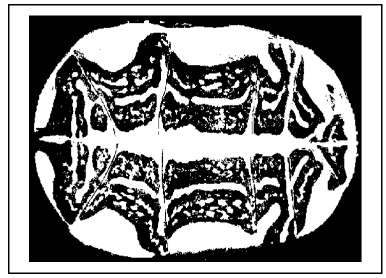


Figure 3 - Preprocessing Complete

After preprocessing, morphological erosion was applied using a horizontal line structuring element. The vertical components and components with small major axes were removed. By selecting the component with the greatest eccentricity, the centre line of the turtle was successfully identified for 62 of the 69 images. The binary image of the turtles were then centered and rotated based on the centroid and orientation of the centre line component. Fig 4. shows the result of the template creation process.

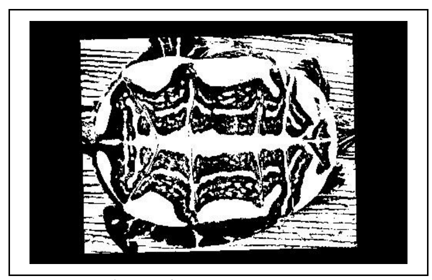


Figure 4 - Template Image

To compare the images of the turtles, the center component of each template was selected. This was first implemented by selecting the connected component that touched the centre pixel of the image. This was only successful for 59 for the 62 images. In 3 cases, no component of the binary image touched the centre pixel. Though the templates were created such that the centre line of the turtles was shifted to the middle of the image, there were minor discrepancies as this was based on the shape of the centre line after multiple morphological operations. Though this did not place the centre line perfectly at the centre of the image in all 62 cases, by selected the connected component with the smallest Euclidean distance from the centre pixel, the connected component containing the centre line was successfully identified in all 62 cases. The result of this process is shown in Fig. 5

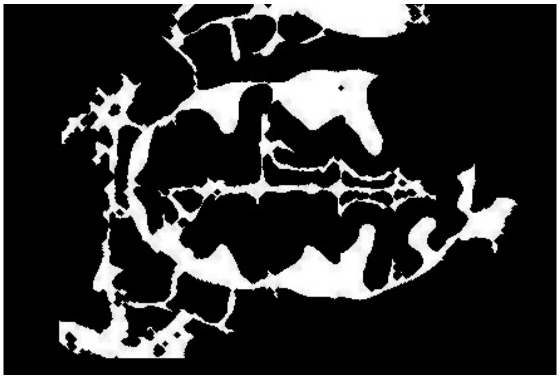
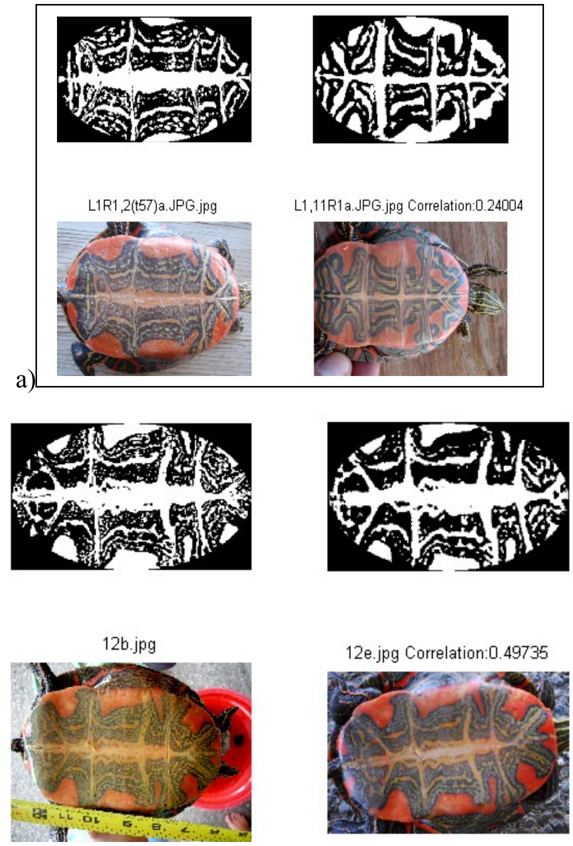


Figure 5 – Connected component touching centre pixel of template image

Morphological opening with a disk structuring element was applied to separate the centre line form the rest of the component. Any components that did not cross the horizontal centre line were removed and the centre was closed using a horizontal line structuring element. A masking ellipse was fit to the image with its centre positioned at the centroid of the centre line. The semi-major and semi-minor axes of the ellipse were determined based on the major axis length of the centre line component to ensure uniformity among all the images. The images were then cropped and resized to all fit the same dimensions and resolution. In this way, it was possible to account for images of turtles of varying sizes and position in the images. The result of this processing step is shown in Fig 6.

Figure 6 - Image cropped and resized with elliptical mask applied

The image in question was then compared to the rest of the images in the database by finding the correlation coefficient. The correlation coefficient of each image is stored and then the three images with the highest correlation coefficients are chosen as the best matches. Fig. 7a) shows the comparison of two different turtles. The original images are shown in colour on the bottom, and the binary images resulting from the described algorithm are compared using the correlation coefficient. Fig. 7b) shows a comparison between two different images of the same turtle. The correlation coefficient in this case is significantly higher as expected.



b)

Figure 7 – Correlation between two images after processing

Fig. 8 is an example result for comparing image L1R1,2(t57)a.JPG against the database. The top match is another image of the same turtle. The 2nd and 3rd match are different turtles as in this case, there were only two images of the turtle in question. Unfortunately, for more than half of the turtles, there were only two images available for comparison.

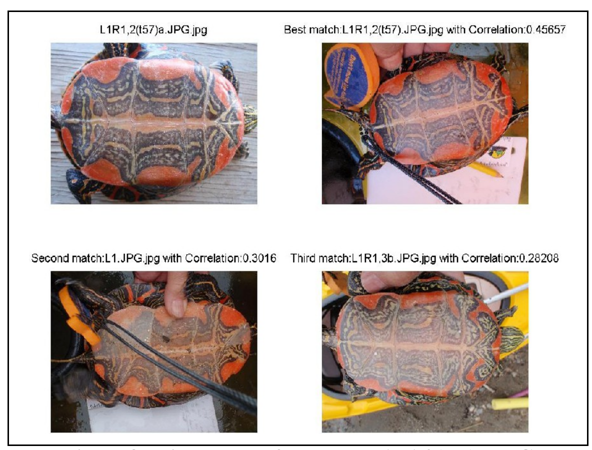


Figure 8 - Final Result for Image L1R1,2(t57)a.JPG

In cases where the applied algorithm was not successful in identifying the whole centre line, but rather a portion of it, the images were not centered properly or scaled correctly and it was not possible to identify the turtle. This was most prevalent for images where the turtles were more off axis than others and the horizontal structuring element eroded entire portions of the centre line. This problem also arose for six images of two turtles that had faint and thinning centre lines. Errors in matching also arose from artifacts such as thumbs present on the shell of the turtle.

Conclusions

The results after comparing 62 images of turtles are:

- When looking among the top three matches, the correct turtle was identified for 33 of the images (53%).
- When looking at the top match, the correct turtle was identified for 26 of the images (42%).

Active contouring was successfully implemented to remove influences from the background. This step, however, was not needed for images with a regular background. For images such as those with horizontal wood grain in the background, failure to remove the background would lead to misidentifying the centre line.

Artifacts that were across the turtle, such as string or thumbnails, gave varying results depending on the location of the artifact. Thumbs on the edges of the turtle did not impede the performance, but any object lying over top of the turtle would hinder finding a match.

By comparing images of a standard size, we obtained good results, but some turtles were not distinguishable from the others, as seen in Fig. 8. This is due to comparing the whole turtle to the other turtle, which does not distinguish faint differences. These false positives were typically of turtles which were difficult to distinguish from each other with the human eye.

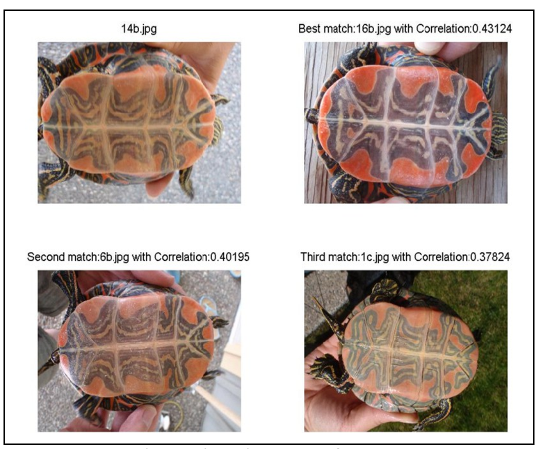


Figure 6 - Mismatch of Turtles

F. Recommendations

One possible way to improve the number of correct matches is to segment the images and compare each segment with each other. This would minimize the influence of artifacts lying on the turtle by using the mean results from comparing many segments.

If this approach to tracking turtles would be implemented, it would be good practice to have the photographers follow some guidelines:

- No artifacts lying on the turtle
- Backgrounds should be consistent

These guidelines would increase the accuracy of the results and would eliminate the need for active contouring in the preprocessing stage.

Acknowledgements

Coding – Kirsten Dohmeier
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References

[1] James C. Russell, Nils Hasler, Reinhard Klette, and Bodo Rosenhahn, “Automatic track recognition of footprints for identifying cryptic species,” Ecology, vol. 90, no. 7, 2009, pp. 2007-2013.

[2] Ritwik Kumar. (2010, Jun.). Snakes: Active Contour Models [Online]. Availiable: http://www.mathworks.com/matlabcentral/fileexchange/28109-snakes-active-contour-models