Posture Data Automatic Extraction of Ornamental Turtle Based on Computer Vision Technology

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Abstract. The posture data of ornamental turtle is a quantitative index to evaluate the quality of the turtle. From the young turtle to the adult turtle, the posture data is constantly changing and the quality can also change accordingly. An integrated observation platform is designed and implemented. The automatic extraction of five posture data, i.e., the length of carapace, the width of carapace, the height of carapace, the length of plastron, and the width of plastron, is realized by using OpenCV based computer vision technology. The results of the experiment and the data of artificial measurement were compared and analyzed. The average fitting degree of the two values reached 99.2%. This method can extract the posture data of ornamental turtle quickly and accurately, and then track its growth and development. It will greatly reduce the workload of data collection in the process of ornamental turtle breeding, and effectively improve the accuracy of data collection. At the same time, it will reduce the risk of damage, and have important production and application value.

Keywords. Ornamental turtle; posture data; observation platform; computer vision; automatic extraction.

1. Introduction
The small freshwater ornamental turtle has regular color patterns on its carapace and pure or complex patterns on its plastron. It is highly valued by pet lovers and has a high market value. The quality and market value of ornamental turtle are determined by the differences in body shape. The ornamental turtles with harmonious body shape proportion and no damage have higher quality and market value. At present, in the market and various appreciation games of tortoise, the shape evaluation of the ornamental turtle is based on the on-site evaluation of experts and senior players in the industry. Some measuring tools are used to measure the body shape, and finally, the measurement data and evaluation results are given [1]. However, the ornamental turtle is a living animal, and the artificial measurement will bring some external stimulation to it, resulting in the discomfort of the ornamental turtle. If the turtle’s stress response is strong, it is likely to cause the injury of the ornamental turtle, resulting in irreparable losses [2]. At the same time, in the measurement process, it is difficult to cooperate with the manual measurement operation, and the mechanical measurement results will also produce large errors [3]. Due to the different operators, different measurement technology, and experience, it is difficult to give accurate and objective measurement results. Besides, there are a large posture data of ornamental turtles, and the measurement work is cumbersome and time-consuming [4]. For a large number of turtles, it is impossible to carry out the rapid batch measurement, and it is also unable to quickly convert them into digital files, which is not convenient for later data analysis and application [5].
This paper designs a set of system solution, through the observation platform integrated with a high-definition CCD digital sensor, automatic zoom lens, white background plate, sensor bracket, height regulator, calibration line, shooting target base, level instrument, USB data line, and other components, to obtain high-definition digital images of ornamental turtle, including the top view of the carapace, side view of the carapace and bottom view of the plastron [6-9]. A software platform for posture data automatic extraction of the ornamental turtle based on the computer vision algorithm was developed to realize data calculation, analysis, and digital storage [10]. Experiments show that the technical scheme designed in this paper can effectively avoid the risk of damage caused by artificial mechanical measurement, and the measurement data is more accurate. The measurement operation process is more simplified and can provide users with digital analysis and application means of the ornamental turtle posture data.

2. Material and Method

2.1. Design and Implementation of Observation Platform
A set of stereo observation platform (figure 1) is designed and implemented, which is suitable for image spatial geometry calculation. It is mainly composed of the following parts:

The white horizontal background board can eliminate the background noise of the image as much as possible, and improve the efficiency and accuracy of the algorithm. The calibration line is set in the designated area of the white background board. The calibration line is a black straight line with a length of 1cm, which is parallel to the horizontal axis of the target base (the central axis of the carapace, the central axis of the plastron, and the side floor line of the target (ornamental turtle) should be placed approximately horizontally with the horizontal axis of the base). It is used for automatic conversion of pixel size and real measurement size in the calculation results.

A 5.0 megapixel CCD image sensor and a OV5647 chip are used. The angle of the view field is 75.7° and 1080p high-definition image acquisition can be realized. The sensor is equipped with an automatic zoom lens. When collecting the same batch of turtle images, it does not need to adjust the attitude of the sensor and the platform, to ensure the consistency of the data acquisition standard for the same batch of turtle images.

The sensor bracket with stainless steel mechanical structure for fixing and erecting the image acquisition terminal is designed. The telescopic adjusting rod with adjustable tilt angle can adjust the observation height through the height adjuster. The horizontal supporting rod is equipped with a level instrument to ensure the level of the sensor image acquisition plane.

The base of the target is an acrylic transparent material base with a level instrument. According to the shape characteristics of the turtle, a bowl structure with a central groove and a raised edge is designed to support the target turtle safely and stably.

The high-definition CCD digital sensor is connected with the computer through a USB data line and transmits the collected digital image to the local disk in real-time. The computer stores the data in the folder directory designated by the local disk in batches, and provides it to the later computer software platform for automatic extraction of posture data.

2.2. Algorithm Design and Implementation
The software module reads the image collected by high-definition CCD digital sensor in batches and extracts 5 posture data in batches. The extraction results are automatically saved in an Excel file of the local computer disk.

The algorithm takes the upper left corner of the image as the coordinate origin, the right as the X-axis, and the down as the Y-axis, and establishes the pixel image coordinate system corresponding to computer graphics. All mathematical calculations are based on this coordinate system.
Figure 1. Observation platform. 1. White Background Board, 2. CCD Camera, 3. Camera Bracket, 4. Height Adjuster, 5. Calibration Line, 6. Target Base, 7. Level Instrument, 8. USB Line, 9. Computer, 10. Target (ornamental turtle).

2.2.1. Calculation of Calibration Factor. The calculated pixel size in the image needs to be converted to the actual size by image sensor imaging geometry. In this paper, a calibration factor $\alpha$ is designed to replace the complicated geometric calculation of imaging and to eliminate the geometric uncertainty caused by automatic zoom. The pixel length $L_{\text{pixel}}$ is calculated according to the pixel of the calibration line with the actual length of 1 cm on each image to determine the conversion ratio between the pixel size and the actual size. Finally, all the pixel sizes calculated from the image need to be multiplied by the calibration factor $\alpha$ and converted to the actual size.

The calibration line is located in the designated area of the white background plate (figure 2), and the area is cut out separately by automatic image cutting.

![Figure 2](image)

Figure 2. Calculation of calibration factor.

The horizontal calibration line is extracted by the horizontal line detection algorithm of computer graphics, and the pixel distance $L_{\text{pixel}}$ (equation (1)) between the two endpoints (P1, P2) of the line segment is calculated. The actual length of the calibration line is specified as 1 cm, and the calibration factor $\alpha$ is calculated as (equation (2)):

$$L_{\text{pixel}} = \sqrt{(P1.x - P2.x)^2 + (P1.y - P2.y)^2}$$

$$\alpha = 1/L_{\text{pixel}}$$

2.2.2. Data Extraction Algorithm of Carapace. Because the background of the image is close to white, the gray value is very large, and the color of the top view image including the head, tail, and limbs that may extend out of the carapace, is a dark and colorful pattern. The gray value has a great contrast with the image background. The ornamental turtle body is extracted from the background by using a gray threshold segmentation algorithm in the top view image. The outermost contour detection algorithm is used to extract the outermost contour. Step by step detection algorithm is used to detect all the points on the contour. The slope change value of each contour point is monitored pixel by pixel, and the threshold value of the slope change value is set. The contour points beyond the threshold value are marked as the inflection points between the turtle's limb extending out of the carapace and the contour points of the carapace. Remove the limb contour points between the inflection points, the remaining
Contour points are the carapace contour points and draw the carapace contour again. In the binary image, the highest contour point $P_{\text{top}}$, the lowest contour point $P_{\text{bottom}}$, the leftmost contour point $P_{\text{left}}$ and the rightmost contour point $P_{\text{right}}$ are extracted (figure 3).

![Figure 3. Data extraction of carapace.](image)

Because the carapace contour is symmetrical with the horizontal axis of the base, the systematic error caused by the slight inclination of the ornamental turtle and the asymmetric points on the contour edge can be suppressed by calculating the distance between the points perpendicular to the coordinate axis (figure 4). Therefore, the length of the carapace $L_{\text{carapace}}$ (equation (3)) and the width of the carapace $W_{\text{carapace}}$ (equation (4)) can be calculated as:

$$L_{\text{carapace}} = (P_{\text{right}, x} - P_{\text{left}, x}) \times \alpha$$  \hspace{1cm} (3)

$$W_{\text{carapace}} = (P_{\text{bottom}, y} - P_{\text{top}, y}) \times \alpha$$  \hspace{1cm} (4)

![Figure 4. Data calculation of carapace.](image)

2.2.3. Data Extraction Algorithm of Plastron. The plastron of the ornamental turtle is a light color, with no pattern or complex pattern, which has obvious contrast with the color gray value of the ornamental turtle body and carapace edge. The image of the plastron area can be extracted completely by the gray threshold segmentation algorithm, and then the plastron data can be calculated. Because the background of the image is close to white and the gray value is very large, and the color of the bottom view image includes the head, tail, and limbs that may extend out of the plastron is light, dark, and colorful patterns. And the gray value is very different from the background of the image. The gray threshold segmentation algorithm is used to extract the ornamental turtle from the background in the bottom view image. The outermost contour detection algorithm is used to extract the outermost contour. Because the center of the view is the inscribed circle with the largest contour radius, the center of the inscribed circle is obtained by calculating the maximum inscribed circle of the outermost
contour of the view. The center of the inscribed circle must be located in the inside area of the plastron. The gray value of the point is extracted as the threshold value of the gray threshold segmentation algorithm for extracting the plastron. The gray threshold segmentation algorithm is used to segment the complete image of the plastron and extract its maximum contour. In the binary image, the highest contour point $S_{\text{top}}$, the lowest contour point $S_{\text{bottom}}$, the leftmost contour point $S_{\text{left}}$ and the rightmost contour point $S_{\text{right}}$ are extracted (figure 5).

Figure 5. Data extraction of plastron.

Because the plastron contour is symmetrical with the horizontal axis of the base, the systematic error caused by the slight inclination of the ornamental turtle and the asymmetric points on the contour edge can be suppressed by calculating the distance between the points perpendicular to the coordinate axis (figure 6). Therefore, the length of the plastron $L_{\text{plastron}}$ (equation (5)) and the width of the plastron $W_{\text{plastron}}$ (equation (6)) can be calculated as:

\[
L_{\text{plastron}} = (S_{\text{right}}.x - S_{\text{left}}.x) \times \alpha
\]

\[
W_{\text{plastron}} = (S_{\text{bottom}}.y - S_{\text{top}}.y) \times \alpha
\]

Figure 6. Data calculation of plastron.

2.2.4. Height Data Extraction Algorithm of Carapace. Because the edge of the carapace is not completely horizontal, when calculating the height of the carapace, the side image of the head side with less display on the bottom plate is selected, and the height of the carapace is extracted by calculating the inscribed circle (figure 7). Because the background of the image is close to white, the gray value is very large, and the color of the side view image including the head, tail, and limbs that may extend out of the carapace, is a dark and colorful pattern. The gray value has a great contrast with the image background. The ornamental turtle body is extracted from the background by using a gray threshold segmentation algorithm in the side view image. The outermost contour detection algorithm is used to extract the outermost contour. Since the most central position of the profile is the inscribed circle with the largest radius of the extracted profile, the maximum inscribed circle of the outermost profile of the ornamental turtle is calculated first. The contour point is searched upward from the circle center $P_{\text{circle}}$ of the largest inscribed circle. If the contour point $P_{\text{contours}}$ whose distance from the circle center is greater than the radius of the inscribed circle $R_{\text{circle}}$ appears just above the circle center, the point is regarded as the highest point of the side profile image, and the height of carapace $H_{\text{carapace}}$ (equation (6)) can be calculated as:
Hcarapace = ( Pcircle.y - Pcontours.y + Reircle ) × α  

(7)

Figure 7. Height extraction of carapace.

3. Result and Analysis
In this paper, 20 Eastern brocade turtles were used as the experimental objects. The five posture data of the length of carapace, the width of carapace, the height of carapace, the length of plastron, and width of the plastron were automatically extracted by observation platform and software module, and the comparative data were obtained by synchronous manual measurement. Through numerical analysis, the five data showed a good fitting state (figures 8-12), and the average fitting degree reached 99.2%.

Figure 8. Numerical analysis of the carapace length.

Figure 9. Numerical analysis of the carapace width.

Figure 10. Numerical analysis of the carapace height.
4. Conclusion
In this paper, through the integrated design of the observation platform and computer vision algorithm, the ornamental turtle posture data was get accurately, efficiently, and automatically. The principle of data extraction with unified standards is adopted to get rid of the subjective factors of artificial intervention. The algorithm of computer vision adopts the method of calculating pixel by pixel, so the numerical accuracy is higher. It solves a lot of data batch processing problems and eliminates random error and operation error to a certain extent. At the same time, it reduces the external stimulation to the high-value ornamental turtles and effectively reduces the operational risk of the data measurement process. To sum up, the technical scheme designed in this paper is of great significance to improve the data acquisition technology of high-quality ornamental turtle posture.

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