Evaluate the viscosity of small aquaculture water by computer vision technology

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Abstract. The royal goldfish has high ornamental value and is usually cultured in small aquaculture water, which requires high water quality. In the industry, water viscosity is usually used to measure the quality of water quality. The fresh and suitable water is conducive to the survival and reproduction of the royal goldfish, while the water with excessive viscosity is easy to cause the royal goldfish to get sick or even die. In this paper, the computer vision technology is used to track and detect the bubble group on the surface of the royal goldfish small aquaculture water in real-time, and the time change fitting model of the bubble group covering the water surface area is established, which can directly reflect the change of the bubble burst rate of the small aquaculture water. Based on this, the viscosity level of the small aquaculture water is quantitatively evaluated. The experimental results show that the coefficient a in the fitting model is highly correlated with the viscosity level. This method can evaluate the viscosity of small aquaculture water in real-time and automatically, and send early warning information to aquaculture technicians quickly, which is of great significance to ensure the health and safety of royal goldfish culture.

1. Introduction
Royal goldfish are usually cultivated in small wooden or ceramic basins, and they are not happy to move or not. The water filtration and oxygen-adding equipment need to work continuously to ensure the water quality at a better level. The surface air environment, food, excreta, algae, and other microorganisms act on the aquaculture water environment. Even if continuous filtration and regular water exchange, it is difficult to ensure that the royal goldfish aquaculture water is in a relatively "fresh and appropriate" state. The viscosity of water is a key index for royal goldfish breeding professionals to evaluate the "fresh and appropriate" state of water. Once the water viscosity is too high, the royal goldfish will soon get sick. If it is not found in time and the water is changed for rescue, it is likely to cause the death of the royal goldfish and bring great economic losses to the farmers. Generally, the method of assessing the viscosity of the royal goldfish aquaculture water is to observe the water state by professionals. Most of the time, even if the water viscosity is already very high, the visual state of the small-scale culture water of the royal goldfish is still clear and transparent, which is difficult to be observed by naked eyes. After years of practice, experienced breeding technicians have summed up a method to judge whether the water viscosity is too high by the change of water bubble state generated by the oxygen enrichment equipment (working 24 hours in the royal goldfish small aquaculture mode). It is considered that when the bubble floats on the water surface, it can not automatically burst in a short time, but when it gathers into a cluster and stays on the water surface for a long time, the water viscosity will be higher, so it is necessary to change water or replenish new water to reduce the water viscosity. On the contrary, when the bubble...
floats to the water surface, it can be quickly and automatically destroyed, and the aggregation group is rarely gathered and the residence time is short. Therefore, the water viscosity is appropriate, and no water change or water replenishment is required.[1] But the method of artificial observation of the bubble state on the water surface has many problems, such as the difficulty of observation and judgment, and the difference of the judging results. It needs long-term and frequent observation and statistics, which is very heavy and cannot achieve real-time and accurate monitoring and judgment, and often delays the rescue time, resulting in unnecessary losses.

A system solution was designed in this paper. The optical image of the royal goldfish small aquaculture water was obtained in real-time by a high-definition CCD digital sensor. Based on the computer vision technology, the analysis algorithm of the apparent optical image of the water is developed, which automatically analyzes the apparent optical image of the water obtained in each period, and extracts the area, and the change rule of the water bubble area. By setting the threshold value of the relationship between bubble shape and water viscosity, the water viscosity analysis results are obtained, and the water viscosity warning information is sent to the user's mobile app client in real-time. Experiments show that the solution designed in this paper can effectively solve the technical problems of traditional manual observation and judgment, such as difficulty, low accuracy, tedious work, time-consuming, and unable to a real-time warning.

2. Material and Method

2.1. Design and Implementation of Observation Platform
The functional module design of the whole small aquaculture water viscosity evaluation system is shown in Figure 1, and the system layout scheme is shown in Figure 2.
Using frame exposure, a 2/3 CCD high definition image sensor whose highest image resolution is 2456*2058 is equipped with an 8mm fixed focus lens. The aperture adjustable range is F2.0–F16. The field angle is $68^\circ *57^\circ *44^\circ$. The focus range is 0.15m–∞. At the same time, it is equipped with a white LED light source, which uses a DC24V power supply to supply light to the water surface at night or when the light is weak. The sensor module is connected with the workstation through a gigabit ethernet port and powered by DC12V.

The workstation adopts compact metal grid high-efficiency cooling box and uses a DC12V power supply. The image acquisition card adopts the MV-EGigE series gigabit network acquisition card, adopts the PCI-E bus standard, ensures transmission efficiency, and realizes high-speed and stable image acquisition. A 128G-SSD high-speed solid-state hard disk can realize the local cyclic storage of images, cooperate with 8G-DDR4 memory to support the local deployment and execution of computer vision algorithm, and save the historical data of water viscosity analysis. Intel I5-7200U high-speed CPU is used to realize efficient image data processing and analysis. WiFi LAN is used to forward and push data between the workstation and the app client. The workstation is equipped with a WiFi wireless routing module and antenna to establish wireless LAN hot spots, covering 100 meters around the workstation. In addition, if necessary, a wireless router can be added to bridge the network signal to expand the coverage of WLAN. The image data processing and analysis of the computer vision algorithm are completed in the workstation.

2.2. Algorithm Design and Implementation

The collected image data is in JPG compression format, and the overall background of the image is water surface. The aerated gas stone works below the water surface, and the generated bubbles emerge from the installation point of the aerated gas stone, forming a bubble group in the water surface area. When the viscosity of water is appropriate, the bubble group will not accumulate and spread to other areas. Under the condition of constant working intensity of oxygen adding equipment, the area of the bubble group in the water surface coverage area will not be changed. On the contrary, when the water viscosity exceeds the standard, due to the higher water film viscosity, the bubble burst becomes slower, and the bubble group will accumulate and drift to other areas due to the water flow reasoning. At this time, the area covered by all bubble groups in the image will show an obvious increasing trend when the working intensity of the oxygen enrichment equipment remains unchanged.\cite{2}~\cite{4} Based on the above phenomenon, a computer vision algorithm is designed to process and analyze the water surface image.

Starting from the trigger time of the system (the trigger cycle of the system can be set as 5 minutes, 10 minutes, and 15 minutes by software on the workstation), all the optical images of water surface collected by the image acquisition card in a water viscosity judgment cycle (within 2 minutes) are extracted. According to the setting of the image acquisition card, 40 ~ 60 optical images can be extracted. An example of a bubble group region image is shown in Figure 3.

![Figure 3. Bubble group on the water surface.](image)

The image brightness of the bubble region is significantly higher than that of the water background. Gray threshold segmentation is performed on the image one by one, and the Canny operator of the
OpenCV computer vision algorithm is used for edge detection to extract the contour of all bubble groups (Fig. 4).\textsuperscript{[5]‒[7]}

Each bubble group is identified according to each closed contour curve. The pixel area of all bubble groups ($S_{\text{bubble}1, \text{bubble}2, \text{bubble}3... \text{bubble}i$) in each image is calculated one by one (Fig. 5). The sum of the pixel area of the water bubble group area at each image acquisition time ($\sum_{i=1,2...i} S_{\text{bubble}i}$) is obtained by adding (Formula 1). $\text{bubble}i$ is the index of the bubble group. $i$ is the natural number from 1 to the total number of the bubble groups.\textsuperscript{[8][9]}

Image acquisition time is taken as the independent variable. $\sum_{i=1,2...i} S_{\text{bubble}i}$ is taken as the dependent variable. The variable data calculated from all images in a water viscosity judgment period
are fitted linearly. The working efficiency of oxygen-adding equipment is fixed in a water viscosity judgment period. Theoretically, the new production of bubbles per unit time is certain. The linear fitting model (Formula 2) is used for the total pixel area time-series change data of the residual bubble groups on the water surface.

\[
\sum_{i=1,2...i}^{} s_{\text{bubble}_{i}} = aT_{j} + b \quad \text{(Formula 2)}
\]

\(T_{j}\) is the time \(j\). \(a, b\) is the fitting coefficient.

\(a\) is the slope of the fitting line. It is the total area average change rate of bubble groups in a water viscosity judgment period. This change rate directly reflects the change of bubble burst velocity observed by human eyes. According to the long-term experience of data accumulation, the qualitative evaluation results of water viscosity are phased according to \(a\) value (the phase threshold can be adjusted by the user on the workstation software according to the actual needs).

When \(a \leq 0.05\), output "water viscosity level is safe.". When \(0.05 < a < 0.1\), output "water viscosity rises, please pay close attention!". When \(a \geq 0.1\), output "water viscosity level is in a dangerous state, please take mitigation measures as soon as possible!".

2.3. Mobile App Client
The mobile app client sets the access rights for users, including user name and password. After users log in legally, the software can run silently in the background. From the trigger time of the system to the end of a water viscosity judgment period, the workstation pushes the qualitative evaluation results of water viscosity to the mobile terminal running mobile app client in the LAN through WiFi LAN hot service program. The notification bar pops up the result push information and calls the mobile phone beep audio to prompt the user to view.

3. Result and Analysis
In this paper, the evaluation results of the small-scale royal goldfish culture water viscosity observation system were taken a synchronous detection comparative experiment. During the breeding period, there was no water change and replenishment operation. The water temperature was kept stable, and the aerator continued to operate for 24 hours. In the 7 days, the fitting coefficient \(a\) of the observed data model was extracted in the morning and afternoon of each day. The water samples were taken simultaneously, and the low viscosity liquid viscometer was used for laboratory detection. Comparing the detection results with the evaluation results of the observation system, the detection value of water viscosity and the model fitting coefficient \(a\) increased synchronously, and showed a high correlation (Fig. 6), which was consistent with the early warning behavior of the observation system.
4. Conclusion
In this paper, through the integrated design of the observation platform and computer vision algorithm, accurate, efficient, automatic acquisition of the royal goldfish small aquaculture water surface bubble state image, and its evolution law of mathematical analysis, obtained the qualitative evaluation results of water viscosity. The evaluation results are free from the influence of artificial observation and judgment. The numerical accuracy is higher by the algorithm of computer vision which adopts the method of calculating pixel by pixel. At the same time, the problem of real-time monitoring of water viscosity was solved, and scientific early warning of water viscosity state was provided to users in time, which effectively reduced the risk of royal goldfish breeding. To sum up, the technical scheme designed in this paper is of great significance to the improvement of the royal goldfish intelligent breeding technology.

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