

Automatic Identification Technology of Ship Image based on Computer Vision

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Abstract

This paper introduces the related concepts and historical background of automatic identification of ship images. By introducing the development of the ship image automatic recognition based on computer vision, the paper summarizes the main work and the basic ideas of different automatic recognition algorithms in different dimensions of static and complex environment by analysis and comparison. Moreover, the paper discusses the current popular methods, including ship images recognition based on deep learning algorithm, ship image recognition and annotation based on content. Also, application research prospects are discussed.

Keywords

Image recognition; Ship recognition; Computer vision.

1. Image Recognition

1.1. Introduction of Image Recognition

Image recognition refers to the technology of using computers to process, analyze, and understand images to identify targets and objects in various modes. It is a practical application of deep learning algorithms. At present, image recognition technology is generally divided into face recognition and product recognition. Face recognition is mainly used in security inspection, identity verification and mobile payment; product recognition is mainly used in the process of product circulation, especially unmanned shelves, smart retail cabinets, etc.

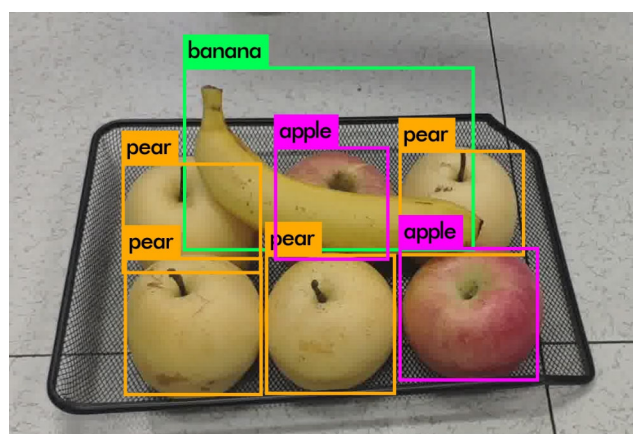


Figure 1. Image recognition example

As shown in Figure 1, the computer accurately recognizes banana, apples and pears in this photo through a certain algorithm. This is a typical example of image recognition.

1.2. Knowledge Base Construction

The ship image recognition process mainly includes ship image feature segmentation and extraction, and feature knowledge base construction. Among them, feature extraction plays a key role in image recognition, and the features should meet the requirements of robustness, scalability, distinguishability and immutability. In the feature extraction stage, optimizing the performance of the algorithm can improve the accuracy of image recognition. In order to achieve the purpose of identifying ships, Wang Chengliang^[1] and other feature extraction algorithms based on the expert knowledge base mainly considers the measurement characteristics of the ship's size, aspect ratio, up-down ratio and complexity. With the help of expert knowledge, a rule-based knowledge base is constructed. The data features in the knowledge base are comprehensively used to discriminate the edges of the image extraction, so as to further identify the ship's target. The ship image recognition technology is applied to the Chongqing section of the Yangtze River, and the experimental results show that the method is superior to the traditional contrast single feature method and the Adobe method. Because the feature extraction algorithm has a simple structure and a small number of feature extractions, it can only guarantee that the identification target is the existing ship records in the knowledge base, and cannot be generalized to ship type identification. Therefore, the ship image recognition method based on feature knowledge base needs to be improved.

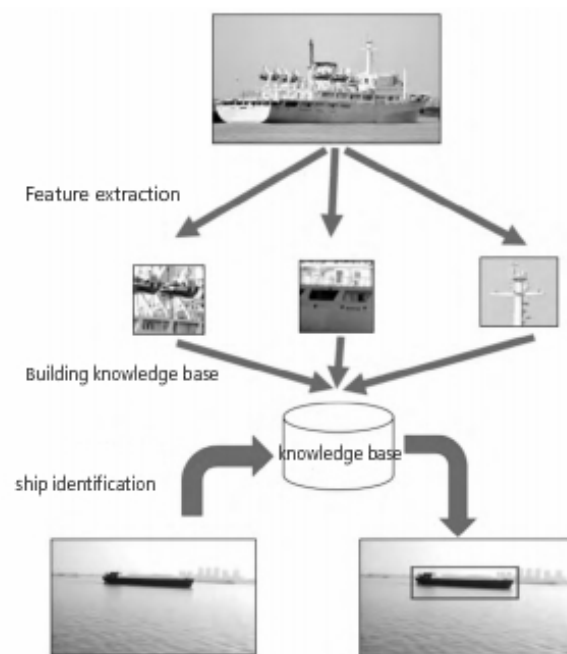


Figure 1. Ship identification process based on feature knowledge base

Figure 2 is the flow of feature extraction and knowledge base construction. First, artificially extract the obvious features of various type of ships, and input them into a knowledge base covering the characteristics of various types of ships to let the computer learn. When a ship needs to be identified, the computer will call the feature items in this knowledge base to verify whether it corresponds to the ship to be identified. If the ship meets all the characteristics of a ship, it can be judged as this type of ship.

1.3. Introduction to Neural Networks

Neural network algorithm is an algorithm that simulates human brain thinking. It is composed of many neurons with adjustable connection weights and has large-scale computing capabilities. The features extracted through image processing are used as the input of the multi-layer neural

network. The neural network uses the BP algorithm(back propagation algorithm) to divide the ships into three types: large ships, medium ships, and small ships. Through experiments, it is found that the ship recognition rate after the introduction of BP algorithm has been significantly improved, and the type of ship can be distinguished. Wei Na^[2] designed the three-layer structure of the BP neural network for ship type recognition experiments, and compared the results obtained by the BP neural network with the template matching results. The results show that the recognition rate using the BP neural network algorithm is much higher than ordinary features Extract the recognition method. The neural network algorithm is introduced for ship identification. Although the accuracy of ship identification is improved, most of the experimental samples are static data. Image data will be disturbed by the marine environment. It will make a wrong judgment on the aggregation of ships and the obstruction of foreign objects within a certain range. Can the experimental algorithm be applied to dynamic data? Can the technology be promoted? The CCTV system collects dynamic video and converts the dynamic video taken at different angles into a frame-by-frame static image for processing and tracking. The algorithm requires certain robustness and adaptability.

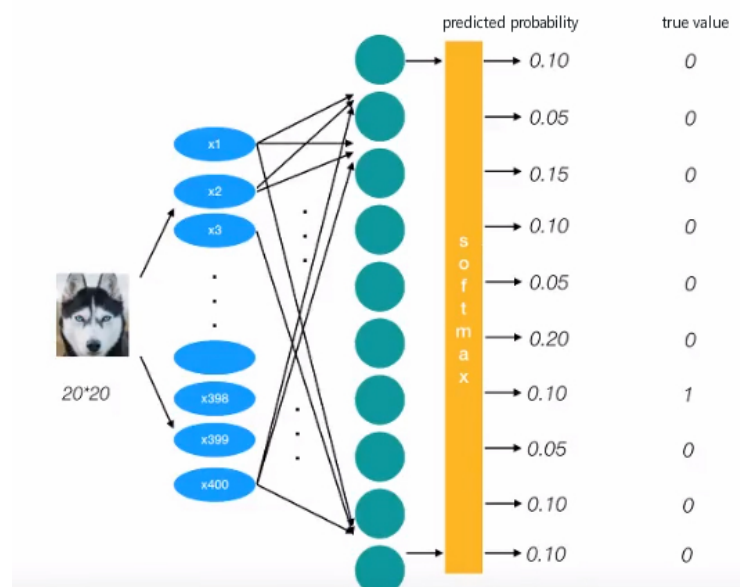


Figure 2. Neural network operation example

Figure 3 is an example of neural network operation. A picture is split into the pixel data contained in the picture. Then enter the input layer, hidden layer, and output layer one by one, and finally compare the output data with the actual data. If the error is recognized, the algorithm parameters are corrected by the back propagation algorithm, and the learning is continued until the output result is correct.

2. Infrared Image Recognition

We found an infrared image as an experimental sample. By studying the infrared radiation law and characteristics, this part summarizes the relationship between the thermal characteristics of the ship and the ship type and direction, compares the infrared characteristics of the ship under different motion states, backgrounds and distances, and extracts the characteristics of the ship under the infrared image for ship identification, as another image recognition scheme. Infrared imaging system has the following five advantages.

1. The environmental adaptability of infrared is better than of visible light. It can work all the time, especially at night and in bad weather(rain, snow, fog), and it has a better ability to penetrate smoke and dust.

2. Infrared non-contact passive detection, good concealment, better security and confidentiality than radar and laser detection, not easy to be interfered.
3. It has high short – term Angle measurement accuracy.
4. It has a long operating distance.
5. Compared with radar system, it has intuitive observation, small size, light weight and low power.

First, let's introduce about the principle of infrared image. Infrared radiation is called infrared light. Infrared radiation is an electromagnetic wave whose frequency is between microwave and visible light. It is a kind of invisible light whose wavelength range is about 0.5 cubic meters to 10 cubic meters. There are three laws for infrared radiation: Planck's blackbody radiation law, Stephen-Boltzmann's law, Lambert's cosine law.

1. Planck's blackbody radiation law describes the spectral distribution of radiation. In physics, Planck's law of blackbody radiation is explained by the relation between the radiant rate and the frequency of electromagnetic radiation emitted from a blackbody at any temperature T. Planck's blackbody radiation law is the basis of all quantitative calculations of infrared radiation.

$$u_v(v, T) = \frac{4\pi}{c} I_v(v, T) = \frac{8\pi h v^3}{c^3} \frac{1}{e^{\frac{h\nu}{kT}} - 1} \quad (1)$$

2. Stephen-Boltzmann's law is the basis of all infrared temperature measurements. The formula is $j^* = \varepsilon \sigma T^4$. The radiation degree j^* has the dimension of power density, and the international system of units standard unit is joule. The standard unit of absolute temperature T is kelvin, and ε is the radiation coefficient of the blackbody. For absolute blackbody, then $\varepsilon = 1$.

3. Lambert's law of cosines explains the spatial distribution of radiation. The radiation intensity of the black body in any direction is proportional to the cosine value of the normal pin on the radiation surface relative to the observed direction. This law indicates that the radiation of the black body is strongest in the normal direction of the radiation surface.

The difference between the radiation rate and temperature of different objects indicates the relationship between the distribution of blackbody radiation intensity and the wavelength at different temperatures. Meanwhile, it also indicates that the maximum peak of the thermal radiation intensity generated by an object with the same oral temperature is around 10μm. In an inland environment, most objects are about the same temperature as normal weather.

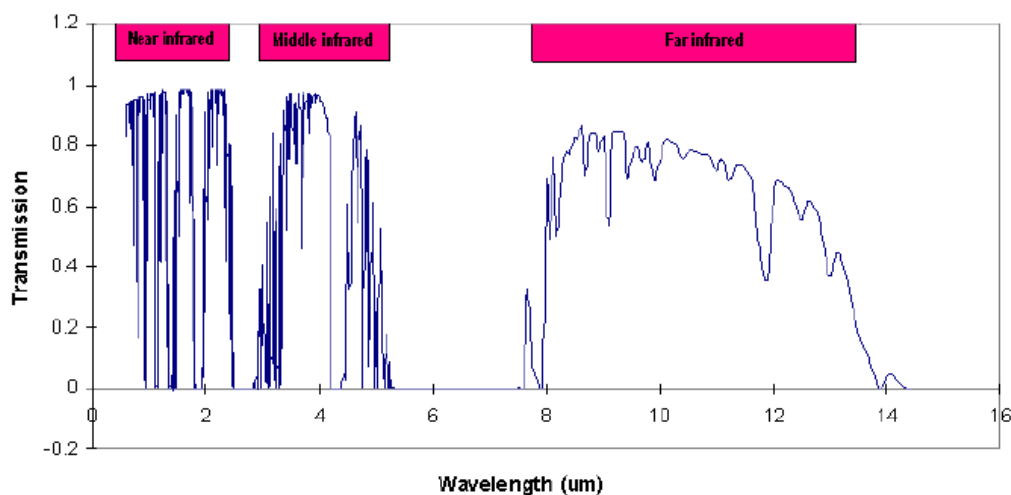


Figure 4. Atmospheric transmission of infrared radiation

For infrared radiation, only a few atmospheric Windows are allowed to pass through the entire range of infrared wavelengths, namely, Near infrared ($0.7\text{-}2.5\mu\text{m}$), Middle infrared ($3\text{-}5\mu\text{m}$), and Far infrared ($8\text{-}14\mu\text{m}$). The sensitive temperature peaks of the infrared detectors corresponding to the three bands mentioned above are 1000K, 500K and 300K respectively. In practical application, the working bands of the forward-looking infrared imaging system can be selected according to the target temperature to be detected and the working climate. In the inland river, the temperature of the stationary ship is about 300K, and the temperature of the heating part such as the moving ship engine and chimney is about 400K. As the photo shows, in the inland river application background, the infrared detector operating at $3\text{-}5\mu\text{m}$ and $8\text{-}14\mu\text{m}$ is preferred.

Different types of ships, due to the use of different engine power, different sizes of ships, different surface materials and their coatings, the corresponding infrared radiation characteristics are also different. The infrared radiation temperature of the main cabin at the rear of the barge and the ro-ro ship and the chimney at the top of the passenger ship are higher than that around the hull, and the infrared radiation is more uniform around the hull of the container ship. Under the same weather conditions, although the hull size of the barge is small, its infrared characteristics are most obvious due to the loose sealing of the engine room. The order of infrared characteristics of other ship types from high to low is: sand dredging ship, ro-ro ship, oil carrier, passenger ship and other ships.



Figure 5. The infrared images of various ships

Generally speaking, the infrared characteristics of the ship running in the same direction in front of the ship are higher than those of the ship running in the opposite direction in front of the ship, that is, the infrared characteristics of the ship's tail are the strongest, the infrared characteristics of the ship's head are the weakest, and the infrared characteristics of other parts are in between.

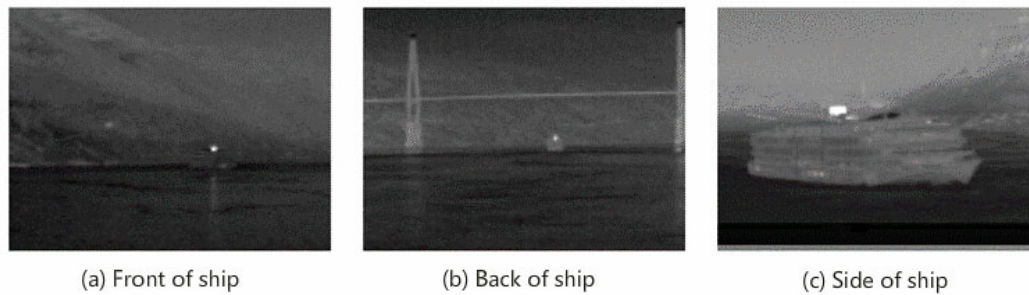


Figure 6. The infrared images of ships under different ship's position

The infrared characteristics of a ship in motion are obviously higher than those of a stationary ship or beacon at berth. When the ship is at rest, the temperature distribution on the surface of the ship is relatively uniform, and the temperature difference between the parts is not big, except that the part heated by the sun or the part reflecting solar radiation has a higher temperature. When the ship is in motion, the heat of the main engine is mainly shown through the following parts: first, the heated part of the hull; The second is the part of the chimney heated by the engine room ventilation gas and the hot exhaust gas of the ascending flue.

As an emerging technology, we can prove its feasibility in the experiment, it is expected to be applied commercially in the future. Further study is needed to prove that the experimental results obtained by infrared image are better than those obtained by visible image. The infrared image needs to establish two data sets for ship identification, it consumes twice as much resources, but we believe that this technology can be commercially used to assist the maritime authority in identifying and controlling ships.

3. The application of Image Recognition in Maritime Domain

Currently, image recognition technology is widely used in security, military, transportation, etc. When it comes to shipping, it involves military and civilian fields such as coast guard, maritime affairs and ship management systems[4]. It is apparent that in the civil-military sphere, video surveillance has become an important source of information. People can extract ship targets from real-time video surveillance quickly and effectively.

This technology helps identify the ship's identity automatically, thus managers could warn the ships with abnormal behaviors in time.

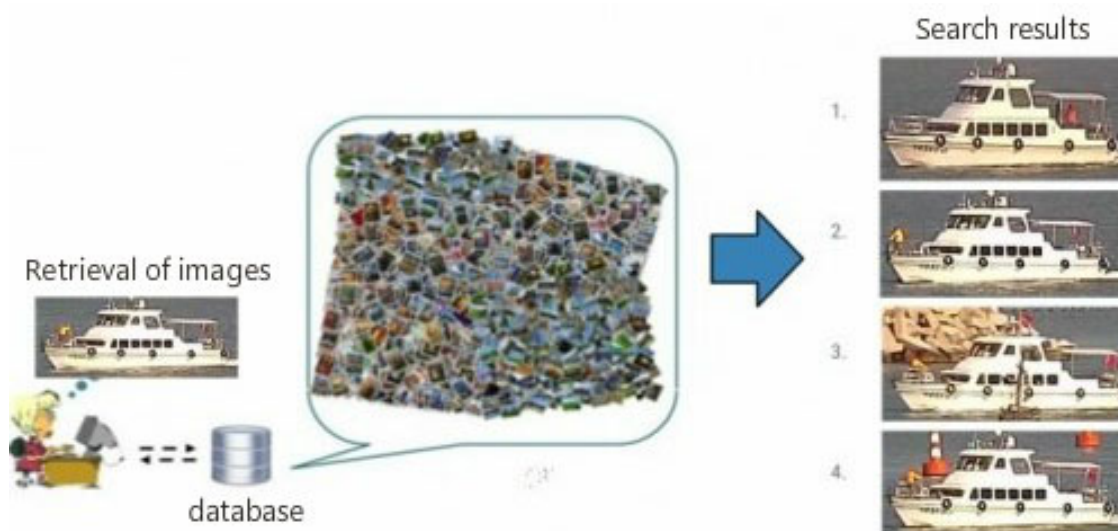


Figure 7. The principles of image recognition technology

According to Figure7, technicians collect pictures of different kinds of ships, and then detach the characteristics of the ships in the pictures, and put them into a database. In practice, we search and recognize ships refer to these features of ships from the database.

We use some method to realize rapid reconstruction and automatic update of the background image. Afterwards, extract the parameter information of the ship target, meanwhile, combine the AIS parameter information to carry out ship identification.

3.1. Examples of Technical Applications

Here are two instances of putting the image recognition technology into practice. The first case was one news released last October, it's about a new vessel image recognition and recording system developed by Japanese shipping giant and technology company SenseTime^[5], and it was installed on a cruise ship for testing.

The second one was issued by the American Bureau of shipping^[6], saying it will cooperate with Google Cloud Computing to develop image recognition software tools to check the signs of hull structure degradation.

4. Conclusion

Artificial intelligence has developed rapidly in recent years, and image recognition is an important field of it, so it naturally developed swiftly as well. What's more, this technology has become widely used in other fields, and it's gradually starting to work in maritime domain. Besides, the advantages of it are also obvious, it opens up the realm of technically achievable functions, and likewise it could improve the efficiency of identification.

Therefore, we are confident enough to believe that in the near future, the application of image recognition technology in maritime ships will be more diversified and the coverage will be wider.

References

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