Paper:

Design and Implementation of Situation Plotting System Based on Hand-drawn Sketch Recognition

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Abstract. Military symbology sketch is the most natural human-machine interaction way to express human thinking and also an important means to express battlefield situation. Aiming at the problems of sparse data set, low recognition accuracy and difficult model application of military symbology sketch, this paper proposes a situation plotting system based on hand-drawn sketch recognition.Firstly, through the self-developed military symbology sketch acquisition application, the data set is collected. Then the military symbology sketch is trained based on Resnet34 and the trained model is applied to the Web situation plotting system to realize online military symbology sketch recognition. Finally, the feedback mechanism is introduced to promote the correction of the Resnet34 model, so as to further improve the accuracy of sketch recognition and the human-machine interaction efficiency of the situation plotting system.

Keywords: Situation plotting system;Military symbology; sketch recognition;Resnet34

1. Introduction

Sketch is an important way of human-machine interaction, compared with voice interaction, image and text express information more accurately[1, 2].Military plotting is an effective way to express battlefield situation information[3].Situational plotting system is a kind of can effectively reflect the military balance of power in order to make leader decision-making system.However, the WIMP(Windows,Icon,Menu,Point) styles of human-machine interaction is still widely used in the current situation plotting system[4].It requires related personnel to drag and drop frequently, and then edit and modify, which leads to low interaction efficiency and is difficult to meet the needs of modern battlefield.Sketch plotting is easier to understand, you can think while drawing, information is richer, and human-machine interaction is more efficient and flexible[5, 6].

With the constant innovation of technology and development of sketch is increasingly used in military field[7]. The US Military proposed the “Deep Green” project as early as 2007, in which the “plan sketch module” and the “decision sketch module” are the commanders using the sketch to interact with the system [8, 9]. Sketch recognition technology is the core of sketch application[10]. However, sketch lacks rich color details and visual clues and it is more difficult to express sketch features [11]. Therefore, many researchers are committed to the study of sketch recognition in recent years. In the field of situation plotting, Cai [1] proposes a method of hand-drawn irregular military symbology recognition based on structural features and rule base. Yang [3] proposes a military symbology recognition method based on the fusion of attention mechanism and convolutional neural network. A hybrid recognition method based on minimum spanning tree (MST) coverage model is proposed by Deng [4]. A free rotation recognition scheme for hand-drawn military symbology is proposed by Wu[12].The target is to identify the image category and direction angle. Although these methods can realize the recognition of sketch to a certain extent but they still need to extract complex features and face problems such as sparse data set of military symbology sketch. Moreover, most of them compare the recognition rate and there are few real application systems.Most of the situation plotting systems used the mouse to drag military symbology for plotting, which are inefficient and difficult to meet the needs of users[13].

According to the problems of military symbology sketch recognition and application, this paper proposes a situation plotting system based on hand-drawn sketch recognition.Firstly, we developed a data acquisition tool for military symbology sketch based on Android system to collect data sets. Then, we trained military symbology sketch based on Resnet34.We applied the trained model to the situation plotting system developed on the Web to realize online military symbology sketch identification. Finally, a feedback mechanism is introduced to increase the quality of the data set by introducing online recognition and regular retraining of the model is performed to promote the correction of the Resnet34 model. It also can improve the accuracy of sketch recognition and then improve the efficiency of human-machine interactive.

2. Related work

Deep learning technology in the field of image classification, target detection, image segmentation has achieved good effect, with the development of deep learning, excellent model constantly emerge.Deep learning technology not only depends on the type and parameters of the model but also depends on the quantity and quality of the data set. From previous experience, it can be seen that the depth of the network has a critical impact on the performance of the model. Research shows that the increase of network layer also brings more features, which can get better results in theory. However, scholars have found that the deeper the network layer, the better the effect is not.With the deepening of the network layer, there will be problems such as gradient disappearance, gradient explosion and network degradation. In order to solve the problem of deep network degradation, He et al,[14] proposed Resnet, the idea is that if those layers behind the deep network are identity mapping, then the model degrades into a shallow network. By learning the identity mapping function, the shallow network is used to approach the deep network. Resnet network is composed of a series of stacked residual blocks, which can reach hundreds or thousands of layers due to its special residual structure.As shown in Fig.1, it is a residual block of Resnet.

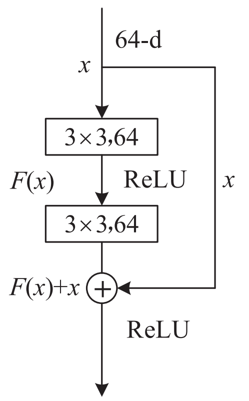

Fig. 1. Residual block

As shown in Fig.1,the input passes through two 3*3 convolution layers to get the output and there is a shortcut on the right to connect directly from the input to the output. The output obtained by convolution operation of the main line is added with the input through the shortcut and the added result is activated by ReLu function.

The network structure of Resnet34 is shown in Fig.2. The left side represents the convolution layer name, the middle represents the parameter settings of the volume layer and the right side is the output size of the output layer.Where Conv2_x、Conv3_x 、Conv4_x 、Conv5_x have 32 layers and the total is 34 layers including Conv1 and the full connection layer.

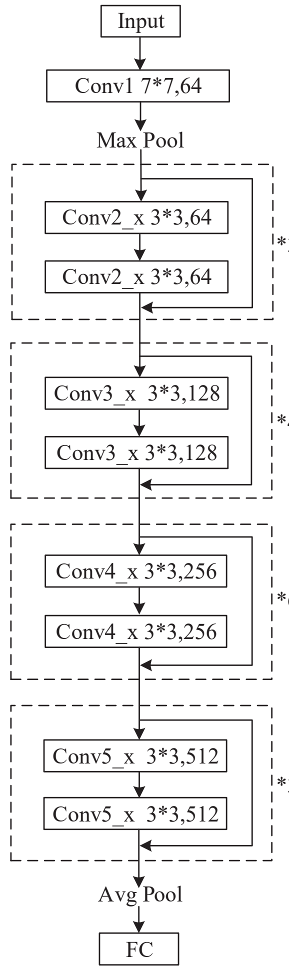

Fig. 2. The network of Resnet34

3. Our work

The process of the method adopted in this paper is shown in Fig 3, which is mainly divided into two parts: data collection and process and model application and feedback.

Firstly,we organizd personnel to collect data sets on the independently developed hand-drawn military symbology sketch data collection application to obtain the data sets. For preprocessing of data sets to ensure correct data can be input Resnet34 network.

Then the processed data was added to the Resnet34 network for training and the trained model was integrated into the situation plotting system on the server. After the military symbology sketch drawn by the user on the Web system, it will be passed to the server, where the trained model recognition will give the TOP6 possible pre-selection results and the user will select the appropriate results for the situation annotation. This way of interaction without frequent to drag the menu and select properties,users only need to select the results after identification, greatly increase the efficiency of the plotting.

Finally, we record the data plotted by users on the situation plotting system and use feedback mechanism to feed it back to data processing stage. When the military symbology sketch drawn by the user on the Web but the preselected results given by the server do not contain the real results after being recognized by the server model. In this time, the drawn sketch and the corresponding real military symbology can be feed back to the data processing stage through the corresponding function of the menu bar. The feedback not only records the military symbology sketch data of error identification, but also records the data in the process of online plotting by the user. The recorded data is feed back to the data processing stage. In the data processing stage, after the data from the client user is processed, the Resnet34 model is trained regularly and the trained model is uploaded to the server to form a self-learning cycle and promote the recognition accuracy of the model to be better and better.

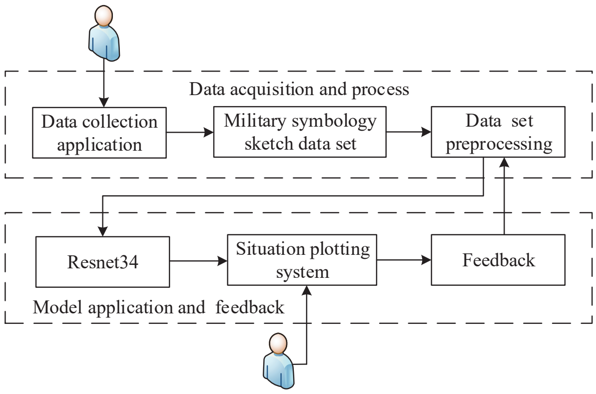

Fig. 3. Process of our method

3.1. Data collection application

In order to facilitate the acquisition of sufficient military symbology sketch data sets, we developed a sketch data acquisition tool based on Android system. As shown in Fig 4, it has a simple interface and rich functions. From top to bottom on the left side of the toolbar are deleted, cancellation, revocation, drawing, color selection, the thickness selection, eraser, the menu bar at the bottom of the display standard military symbology, through the left and right button switch standard military symbology, the middle is to save the military symbology of hand-drawn.

We invited 50 volunteers and used the developed collection tool to conduct the data set of military symbology sketch on mobile and tablet devices. In order to ensure data diversity, the proportion of professionals and non-professionals in the volunteer group was 1:1. During the collection process, the collectors are required to draw with the same uniform thickness and color. Each person draws 3 samples for each standard military symbology. During the collection process, the current hand-drawn military symbology can be corrected by withdrawing, deleting and altering, etc. After clicking“Save”, the collected hand-drawn data will be stored in the background and a file index will be established. It can be very convenient for the acquisition of military symbology sketch data.

As shown in Fig 5, we collected part of the military symbology sketch samples and standard military symbology. After sorting, we collected a total of 300000 PNG

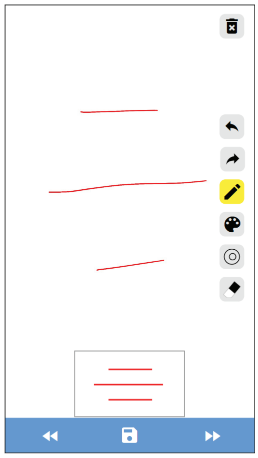

Fig. 4. The interface of military symbology sketch acquisition application

military symbology sketch data sets of 200 kinds of military symbology which were divided into training set and validation set according to the ratio of 7:3.

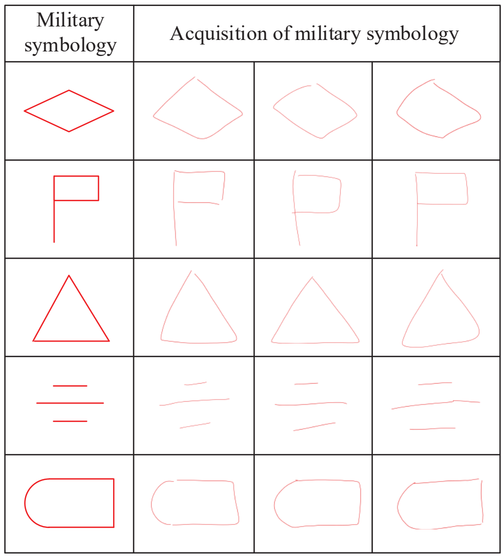

Fig. 5. Part of the military symbology sketch

3.2. Situation plotting system

We developed a situation plotting system based on WebGIS[15], which is used for online situation plotting. The framework of the situation plotting system is divided into data layer, service layer, application layer and presentation layer from the bottom up, as shown in Fig 6. The functions of each layer are as follows:

1)Data layer,it includes geographic information data and situation element model data. Geographic information data is provided based on WebGIS and situation element model data is stored in JSON format for situation plotting.

2)Services layer,it includes GIS server and Web server as well as deep learning model services. The system is built by the way of separating the front and back ends.

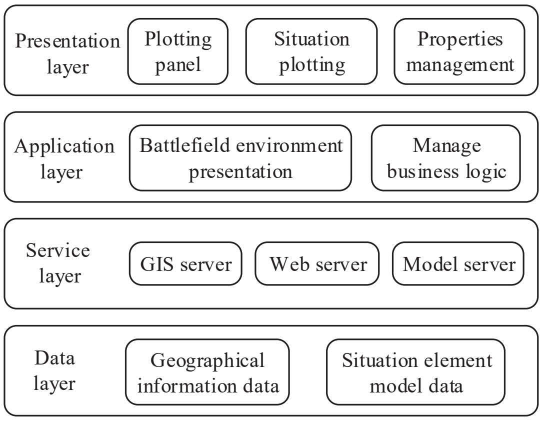

Fig. 6. System architecture of situation plotting system

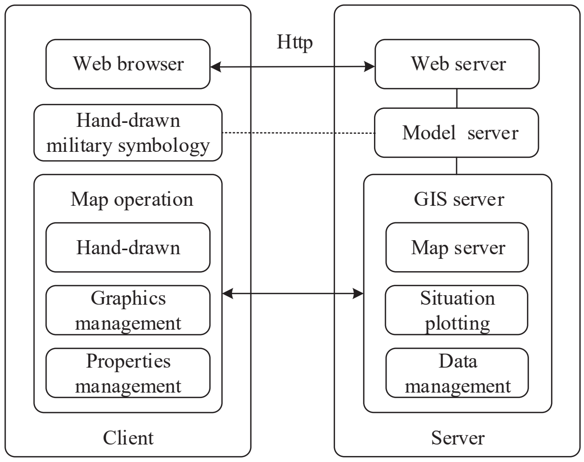

Fig. 7. System logic of situation plotting system

This layer uses standard data format to provide services for clients. The GIS service provides the map service for the situation plotting and the Web server deploys the situation plotting system using Apache Tomcat to provide the interface for accessing the situation plotting data.The model service provides sketch identification results.

3)Application layer,it is the core of the situation plotting system to express the battlefield environment and manage the business logic of the situation plotting. It down with upward request JSON data service layer and the presentation layer interactions, receives the user request, display and edit status symbols and respond to treatment.

4)Presentation layer,it provides the interface display of system functions. The system uses the browser as the interactive window with the user, draws the military symbology by hand-drawn input or drag-and-drop selection and manages the attributes of the symbology.

3.3. System Deployment

The situation plotting system includes server and client[16]. As shown in Fig 7, the server consists of Web server, trained model and GIS server. The server is responsible for basic map service, identification of military symbology sketch and data storage. The client calls the service published by the server and realizes the functions of map browsing, hand-drawing input, graph management and attribute modification.

3.3.1. Client

1)Hand-drawn input,we use canvas for hand-drawing, it's equivalent to a dowlas and providing a high degree of abstraction API. It enables users to control canvas elements in the client and perform pixel-level drawing control on it. By calling the tag of DOM object can be after the"context" graphic drawing, combined with JavaScript that can be easily implemented the function of interactive drawing graphics on a Web page.

2)Graphic management, it will be automatically sent to the server for identification after the user finished the hand-drawn military symbology on the client. The server will return the identification results and the user can make selection.The client will save each selected military symbology as a graphic object. When the basic geometric transformations such as translation, rotation, enlargement and reduction are carried out on the military symbology in the graphic object, the mapping service system is not required to regenerate the vector description, which can be done directly on the client, thus effectively reducing the pressure on the server.

3)Attribute management, it is to manage the attributes of the selected military symbology, including the basic attributes such as the color, size and thickness of the military symbology.It also provides the control point in accordance with the military symbology which is easy to change the style of military symbology by dragging the control point.

4)Map operation, it allows users to add marks on the map and select corresponding military symbology.When zooming in and out of the map, the military symbology needs to zoom in and out with the map. When roaming the map, the military symbology also needs to move with the map.

3.3.2. Server

1)Geographic information services, as for the situation plotting system the GIS service mainly provides the functions of viewing the map in the browser, operating the map and registering the geographical information of the situation symbology.

2)Model of load and predictable service, which responsible for loading deep learning model. It will predict the results back to the client users for their choice after receiving input hand-drawn military symbology.

3)Data management services, it includs user data management and system data management. User data management means that once the server receives the user's request to save data it will store the drawing data and the user's basic information in the data linked list.The system data management service provides the types of military symbology that can be plotted by the client system.

4. Experiment

4.1. Experimental of environment

In this paper, the experimental environment as shown in Table 1:

Table 1. Experimental of environment

Experimental of environment	Version
Operating system	Win 10
Memory/GB	8
CPU	Inter i5-10400F
GPU	NVIDIA GTX1660
Python	3.7
Pytorch	1.7
CUDA	11.0

4.2. Data set preprocessing

Since the quality and quantity of data sets will affect the training effect of deep learning and too few samples are prone to overfitting, this paper adopts the following methods to expand the data sets respectively.

1) Add new data from existing data by means of translation, rotation, mirroring, etc. 2) Expand the data set of military symbology sketch by adding noise. 3) The above methods are all physical ways to increase the data set. Due to the different knowledge background and habits of each person, the presentation of sketch is more flexible. In this paper,inorder to get more form of sketch data,thin-plate spline based on spatial interpolation is used to transform the generated sketch[17], so as to obtain richer military symbology sketch data.

Through the above ways to increase the train and test data sets, we built a data set of 60,000 military symbology sketches. The method of data set amplification can not only increase the number of training samples, but also alleviate the overfitting of the model to a certain extent and improve the generalization ability of the model.

4.3. Experimental parameter setup

In this paper, cross entropy loss function is used to evaluate the error between the model classification results and the actual labels and accuracy is used to evaluate the accuracy of the model classification.The network learning rate is 0.00001,bathsize is 16, epoch is 200 and the optimizer is adam optimizer.

4.4. Analysis of experimental results

This paper respectively to AlexNet[18], VGG16[19], Resnet34 in self-built hand-drawn military symbology data sets for contrast, the loss of the experiment and precision curve comparison is shown in Fig 8 and Fig 9.

In Fig 8, the loss of each model is constantly decreasing and the model learning is good. In Fig 9, the accuracy of each network model is increasing with Resnet34 performing well. It is not difficult to see that the faster loss drops, the faster its accuracy rises, but the relationship between loss and accuracy does not always match.It can be seen from Fig 8 and 9 that although VGG16 has low loss

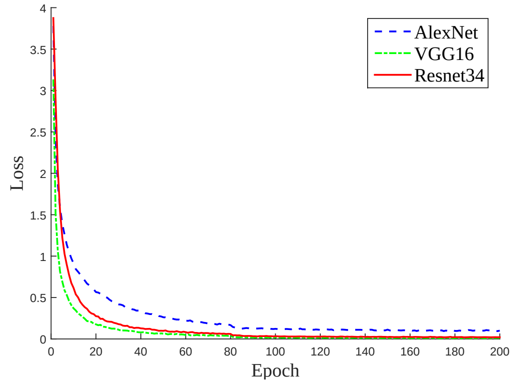

Fig. 8. Loss comparison

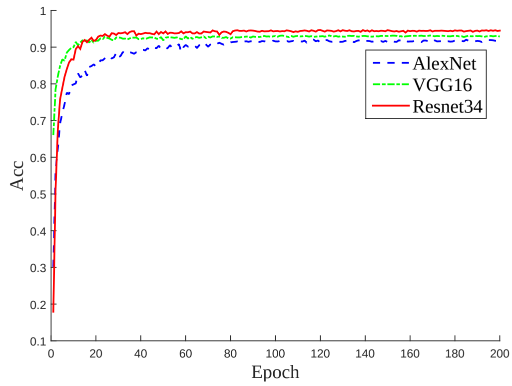

Fig. 9. Accuracy comparison

but its accuracy is not as good as Resnet34. The accuracy of each model is compared as follows:

In Table 2, the Resnet34 has highest accuracy,therefore, this paper deploy the trained Resnet34 model to the server for online military symbology sketch recognition.The human-computer interaction of the situation plotting system is frequent, and its response time greatly affects the user experience. According to the calculation, the recognition time of the server is about 50ms after the completion of each drawing, which makes the user feel smooth and meets the online identification needs of users.As shown in Fig 10,when the user clicks on the hand-drawing input in the browser, the map can be sketched.After the drawing, the drawn graph will be automatically sent to the server, which will give the TOP6 recognition results and present the results to the client and then the user can make a choice.

By established the feedback mechanism and used the online situation plotting system, we obtained some revised military symbology sketch data. After expanding these data by 4.2, we added them to the original data set

Table 2. Accuracy comparison of three models

Model	Accuracy/%
AlexNet	91.73
VGG16	92.87
Resnet34	94.50

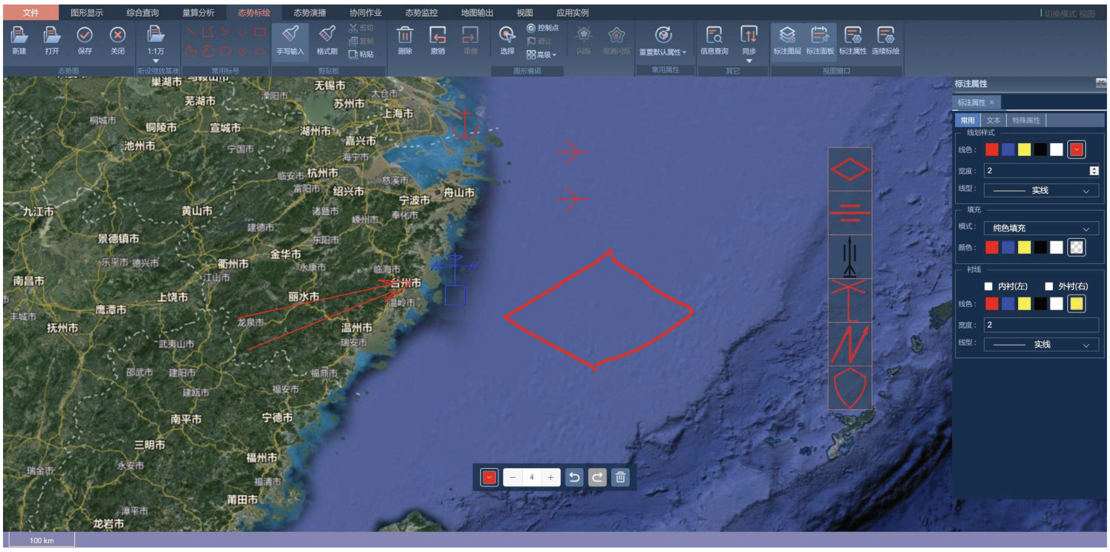

Fig. 10. Situation plotting system

as new data and then conducted the training of the model again. Finally, the accuracy of Resnet34 feedback correction is obtained, as shown in Table 3.

Table 3. Accuracy comparison of two Resnet models

Model	Accuracy/%
Resnet34	94.50
Resnet34+Feedback	95.21

It can be seen that part of the data sets with strong supervision can be obtained through the establishment of online feedback mechanism. Then this part of data is taken as a new data set to retrain the model which can further improve the accuracy of model prediction.

5. Conclusion

This paper constructs an efficient situation plotting system based on sketch recognition and WebGIS technology. Firstly, in order to solve the sparse problem of sketch data set,we develop a hand-drawn military symbology data collection application and invites volunteers to collect data.Secondly, the application of deep learning model is discussed, we developed an online identification situation plotting system and deployed the trained model to the server for online identification of hand-drawn military symbology sketch.Finally, in order to further improve the model recognition accuracy and human-machine interaction efficiency of the situation plotting system, a feedback mechanism is proposed. Which takes the data sets generated by users in the situation plotting system as new data sets and retrains the model and automatically deploys it to the server to improve the model recognition accuracy.

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