Research Article

Brand Marketing Decision Support System Based on Computer Vision and Parallel Computing

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With the rapid development of information technology, decision support systems that can assist business managers in making scientific decisions have become the focus of research. At present, there are not many related studies, but from the brand marketing level, there are not many studies combining smart technology. Based on computer vision technology and parallel computing algorithms, this paper launches an in-depth study of brand marketing decision support systems. First, use computer vision technology and Viola-Jones face detection framework to detect consumers’ faces, and use the classic convolutional neural network model AlexNet for gender judgment and age prediction to analyze consumer groups. Then, use parallel computing to optimize the genetic algorithm to improve the running speed of the algorithm. Design the brand marketing decision support system based on the above technology and algorithm, analyze the relevant data of the L brand, and divide the functional structure of the system into three parts: customer market analysis, performance evaluation, and demand forecasting. The ROC curve of the Viola-Jones face detection framework shows its superior performance. After 500 iterations of the AlexNet model, the verification set loss of the network is stable at 1.8, and the accuracy of the verification set is stable at 38%. Parallel genetic algorithms run 1.8 times faster than serial genetic algorithms at the lowest and 9 times faster at the highest. The minimum prediction error is 0.17%, and the maximum is 2%, which shows that the system can make accurate predictions based on previous years’ data. Computer vision is a technique that converts still image or video data into a decision or a new representation. All such transformations are done to accomplish a specific purpose. Therefore, a brand marketing decision support system based on computer vision and parallel computing can help managers make scientific decisions, save production costs, reduce inventory pressure, and enhance the brand’s competitive advantage.

1. Introduction

1.1. Background Significance. If companies want to quickly improve their core competitiveness in the market, they must conduct appropriate brand marketing and establish a brand image. Brand marketing requires effective use of data to continuously make various scientific and reasonable decisions. Therefore, research on decision support systems that can assist business managers in making scientific decisions is of great significance [1]. Parallel computing is now mainly used in scientific research and image rendering. The graphics card, that is, the graphics processor GPU, is a parallel processor. Generally speaking, parallel computing is to deal with some tasks with slightly less logic but large amount of data. Traditional data analysis and prediction methods often fail to obtain accurate information, which may lead to the failure
of brand marketing strategies. Therefore, it is necessary to study decision support systems based on technologies such as computer vision and parallel computing. Inception’s network structure is shown in Figure 1.

As shown in Figure 1, the Inception structure is a full convolution, and each weight corresponding to each activation value corresponds to a multiplication operation. So reducing the amount of computation means reducing the parameters. So by decoupling and parameters, training can be accelerated.

1.2. Related Work. Computer vision technology and parallel computing have always been research hotspots. Leo et al. focus on a set of cross-application computer vision tasks, which are set as the key to AT classification to meet certain needs of users, and analyze the computer vision algorithms recently involved in AT development [2]. Zhao et al. proposed and implemented a system named Ligraph, which can calculate large-scale graph data with lightweight communication overhead in a distributed mode [3]. Their research has improved the algorithm, but the authenticity of the data used to test the algorithm and system is not high. The research of brand marketing and decision support system has always been the focus of enterprises. Pauwels et al. quantified the dynamic interaction between apparel retailers’ marketing, e-WOM content, search, and online and offline store traffic [4]. Hassani et al. proposed a cluster-based hierarchical framework, including a consensus decision support system for smart grid fault location. They first collected frequency measurements with a distributed frequency interference recorder and then used the associated propagation (AP) clustering technique to divide the grid [5]. Although their research results provide a reference for related research, the research methods are too complicated and difficult to imitate. The shortcut linking is shown in Figure 2.

As shown in Figure 2, cluster analysis refers to the analysis process of grouping a collection of physical or abstract objects into multiple classes composed of similar objects. It is an important human behavior.

1.3. Innovative Points in This Paper. In order to improve the core competitiveness of the enterprise and establish a good brand image, this article has launched a research on the brand marketing decision support system. The innovations of this research are as follows: (1) face detection of consumers based on the Viola-Jones face detection framework. The classic convolutional neural network model AlexNet is used to judge consumers’ gender and age to analyze the characteristics of consumer groups. The model has high accuracy and good performance. (2) Parallel genetic algorithm is used to improve the running speed of the algorithm and save calculation time. (3) Establish a brand marketing decision support system based on computer vision technology and parallel computing. Its functional structure includes customer market analysis, performance evaluation, and demand forecasting. Analyze the customer groups and market positioning of the L brand, evaluate sales performance, and predict sales demand to support relevant decisions.

2. Computer Vision and Parallel Computing

2.1. Key Technology of Computer Vision

2.1.1. Target Recognition Technology. Object recognition refers to the process of distinguishing a particular object from other objects. It includes both the identification of two very similar objects and the identification of one type of object with other types of objects. Target recognition can provide the basis and premise of analysis for decision-making. Target recognition methods include traditional target recognition methods and target recognition methods based on deep learning. In the traditional target recognition method, the original image is preprocessed first, then the image features are extracted manually, feature selection is performed, and finally, the design and training of the classifier are performed [6]. Traditional target detection has the following two main problems: first, the region selection strategy based on sliding window is not targeted, time complexity is high, and the window is redundant; second, the hand-designed features are not very good for diversity changes of robustness.

The image taken with the camera is affected by changes in lighting and noise interference and cannot characterize the feature information of the image. Therefore, it is necessary to preprocess the redundant environmental background information of the image. Commonly used image preprocessing methods include grayscale images, image filtering, and image sharpening. To extract features manually, it is usually necessary to extract multidimensional features of the image and filter a series of the most characteristic original features of the image. The selected features are distinguishable, reliable, and independent in order to obtain good classification results. Finally, the extracted features are sent to the classifier, and a usable classification model is obtained after training. Common classifiers include SVM and AlexNet [7].

The regional neural network first selects several proposed regions for the image and annotates their categories and bounding boxes. Then, a convolutional neural network is used to perform forward computation on each proposed region to extract features. Then, use the features of each proposed region to predict the class and bounding box. The regional convolutional neural network breaks the bottleneck of the target recognition method of deep learning in the field of target recognition for many years. Since then, convolutional neural networks based on region nomination have continued to improve. After the emergence of SPP-net, FasterRCNN, and FasterRCNN, the end-to-end training convolutional neural network is further developed based on the target recognition method of deep learning, the network structure is further simplified, and the recognition speed and recognition accuracy are improved [8, 9]. The overall framework diagram of the ResNet network is shown in Figure 3.

2.1.2. Image Preprocessing. Image preprocessing is to separate each text image and hand it over to the recognition module for recognition. This process is called image preprocessing. In the image imaging process, the imaging system and external factors affect the image imaging quality,
causing specific interference, such as uneven exposure, image noise, and uneven contrast. In order to better complete the recognition task, the quality of the recognition image needs to be improved. In the image field, image preprocessing methods include image enhancement, image filtering, image normalization, and brightness correction processing.

In image processing, the image noise that appears is generally divided into photon noise and readout noise [10]. Photon noise is usually because the light is too strong or too weak. Due to the influence of light quanta, the number of photons received by each pixel will become random. If the exposure is too strong or insufficient, photon noise will be generated. Readout noise is a kind of random noise generated...
by the imaging system circuit. Taking into account the difference in camera system design, the range of reading noise is also uncertain, and it can be large or small. When the brightness is low, read noise is the main noise source.

Image filtering, that is, suppressing the noise of the target image under the condition of preserving the image details as much as possible, is an indispensable operation in image preprocessing, and its processing effect will directly affect the effectiveness and efficiency of subsequent image processing and reliability analysis. Image filtering processing can remove image noise. Mean filtering uses the mean to replace each pixel value in the image. The calculation of the mean is shown in Formula (1).

$$S'(x, y) = \frac{1}{E} \times E \sum_{(i,j) \in R_{(x,y)}} S(x, y). \quad (1)$$

Among them, $S(x, y)$ is the pixel value of the pixel $(x, y)$, $E$ is the size of the mask window, and $R_{(i,j)}$ is the coordinate collection of all pixels in the mask when the center of the mask window coincides with the target pixel.

2.1.3. Face Detection Technology. The Viola-Jones face detection framework lays the foundation of modern face detection methods and marks the formal application stage of face detection. The Viola-Jones face detection framework adopts Haar-like features, which can better capture the features of regional contrast. In the original framework, Haar-like features include vertical 2-rectangular, horizontal 2-rectangular, 3-rectangular, and 4-rectangular [11]. The improved Haar-like features include edge, linear, center surround, and diagonal features. The Viola-Jones face detection framework uses the integral map to accelerate the feature calculation process. First, the original image is converted into an integral map. The conversion process is shown in Formulas (2) and (3).

$$m(a, b) = m(a, b - 1) + i(a, b), \quad (2)$$
$$ii(a, b) = ii(a - 1, b) + m(a, b). \quad (3)$$

Among them, $i(a, b)$ represents the pixel value of a certain point on the original image, $ii(a, b)$ represents the value of the corresponding position on the integral map, and $m(a, b)$ represents the sum of pixels from a certain point on the original image to the upper left corner of the rectangular area. Then, calculate the pixel sum of any rectangular area $G$, and the calculation process is shown in Formula (4).

$$\text{SUM}(G) = ii(f) - ii(e) - ii(d) + ii(c). \quad (4)$$
Among them, $c, d, e, f$ are the corresponding values of the integral diagrams of the four corners of area G.

Although the integral map can shorten the calculation time of a single feature, it cannot use all features for classification. Therefore, the Viola-Jones face detection framework uses AdaBoost to select features and give these features appropriate weights [12]. The Viola-Jones face detection framework also constructs a cascaded classifier, which can increase the detection rate, reduce the false detection rate, and reduce the average time for the subwindow to pass the classifier [13].

### 2.2. Parallel Computing

#### 2.2.1. Parallel Programming Mode

Common parallel programming modes include master-slave, data pipeline, single program flow, multiple data flow, and divide-and-conquer strategy [14]. The master-slave programming model divides the task to be solved into a master task and several slave tasks and assigns them to the corresponding master process and subprocesses. The main process is responsible for decomposing the main task into slave tasks and several slave tasks and assigns them to the corresponding master process and subprocesses. The main factor to consider in this

Table 1: Comparison of serial time and parallel time of genetic algorithm.

| Initial point | Serial time | Parallel time | Speedup ratio |
|---------------|-------------|---------------|---------------|
| 1             | 0.028       | 0.013         | 2.2           |
| 2             | 0.033       | 0.011         | 3             |
| 3             | 0.023       | 0.005         | 4.6           |
| 4             | 0.018       | 0.002         | 9             |
| 5             | 0.021       | 0.004         | 5.3           |
| 6             | 0.016       | 0.007         | 2.3           |
| 7             | 0.018       | 0.010         | 1.8           |
mode is to assign tasks to child processes to avoid unnecessary waiting between child processes.

The data pipeline mode functionally divides tasks into subtasks. Subtasks can complete the calculation of a specific function and form a pipeline. The communication between each process can be completely asynchronous [15]. The basic idea of the divide-and-conquer strategy model is to resolve large and complex problems into several subproblems with the same characteristics. It can be reused until each subproblem can be easily solved. This programming model is naturally used in recursive parallel programming.

The basic idea of the single program flow and multiple data flow mode is that each process executed in parallel executes the same code, but each processed data is different. In this mode, the application data is first allocated to each processor in advance, and then, each processor completes its own computing tasks in parallel. This includes data exchange between processors during the calculation process and finally summarizes the calculation results. The main factor that should be considered in this mode is that the calculation has locality, and the communication overhead caused by excessive data exchange needs to be controlled to a minimum.

2.2.2. Parallel Programming Language Environment. The parallel programming language environment is divided into a shared storage device programming environment and a distributed programming environment. The shared memory parallel programming system adopts a shared variable model. The process of each processor does not require a special communication mechanism and only needs to communicate with each other by reading and writing shared variables in the shared memory. But in order to ensure the correctness of reading and writing, synchronization operations need to be considered.

Distributed programming environment from the perspective of parallel programming, its system is connected to each processor through the Internet, each processor has its own independent local memory, and all local memory constitutes the entire address space [16]. The entire address space has two address assignment methods, local and global. Because the former is the individual addressing of each local memory in the system, the user program space is multidimensional, and remote memory access needs to be implemented by calling the messaging library. The latter is a unified address in all local memories in the system, so the user program space is multiaddressed, and remote memory access needs to be implemented by calling the messaging library. The shared memory model only needs to communicate with the processor and the local memory address.

Therefore, there are two parallel programming modes for distributed storage systems, namely, the message passing mode based on multiple address spaces and the data parallel programming mode based on single address space [18].

2.2.3. Parallel Programming Method. Parallel computing can be divided into 4 levels according to the granularity: command layer, very fine granularity; data layer, fine granularity; control layer, medium granularity, and task layer, large granularity [19]. The first two layers are mainly processed by the hardware and the compiler, and programmers usually deal with the parallel of the latter two layers. Due to different high-performance computer architectures and different memory access modes, there are mainly two different forms of parallel program design methods. One is based on the message passing model, and the other is based on the shared memory model.

The messaging mode means that the user needs to display the reception and transmission of messages in order to achieve data exchange between processors. This method is suitable for process-level parallel operations with large granularity and large-scale scalability. In this parallel programming model, each parallel process has its own independent address space, which cannot be directly accessed between processes and needs to be achieved by passing clear information. The shared memory model is mainly executed in SMP and DSM systems specified by a uniform memory address, with thread-level parallel granularity. The most representative language of this model is OpenMP [20]. By inserting a specific compilation command statement before the loop statement of the serial program, the information that is helpful for parallelization is notified to the compilation system, and the compilation system is forced to perform parallelization according to a specified method.

The improvement of program parallelization usually requires attention to the data dependence of the program. If it has nothing to do with the data, the program is considered to be parallelizable. If there is a correlation, the program cannot be parallelized. Before parallelization, a condition must be created to change this relationship. According to the relevant conditions of the data, decide whether the program can be parallelized. Since the general program cannot avoid the situation related to this data, parallel programming needs to distinguish which part of the program is relevant and which part is not. Perform parallel operations in the data-independent part, and the sequence relationship of the program can be maintained in the data-related part.

2.3. Brand Marketing Decision Support System

2.3.1. Brand Marketing Strategy. The purpose of brand positioning is to occupy a favorable position in the hearts of consumers. Once people have demand, they will think of this brand. Brand positioning includes communication positioning, product positioning, sales channels, services, and communication [21]. If there is no change in the product, only communication positioning, brand positioning is an empty slogan. On the contrary, if there is only product positioning, the product is easy to be imitated and there is no difference advantage. The core issue of positioning theory is the content of positioning, the scope of positioning, and the method of positioning.

Brand competition is actually a brand image competition. Successfully shaping a brand image can connect consumers’ preferences with the brand, and consumers will have a good impression of the brand. The core element of a brand is the name of the brand, which is also the basis for the formation of the brand concept [22]. A good name
can help companies participate in market competition and open up the international market.

The added value of a brand only exists in the perception of consumers. Brand advertising is not only the main method to establish consumer brand awareness, but also an effective method to increase brand awareness. By investing money in advertising fees and advertising on platforms such as TV, radio, and the Internet, the company has deepened consumers’ brand awareness and achieved popularity and consumer expansion. For brand expansion, use the advantages of established brands to promote new products on sale and seize market opportunities. Through brand expansion, the company’s products can be serialized and many products can be merged into a brand system.

2.3.2. Basic Structure of Decision Support System. The basic structure of the classic DSS includes three basic parts, the database and its management system, the model library and its management system, and the dialogue generation management system, which are also called data subsystem, model subsystem, and generation subsystem, respectively [23, 24]. Classic DSS is actually a man-machine system including decision-makers and computer hardware.

With the application of artificial intelligence methods and technologies in DSS, knowledge-based DSS appears, and its structure includes language system, problem handling system, knowledge system, and knowledge base model library [25]. The knowledge system is a decision-making knowledge base management system about the problem domain. In order to generate decision support information, the knowledge system must realize the acquisition, expression, preservation, and management of information and knowledge. This includes model libraries, databases, and knowledge-based compilation, preservation, and management to provide knowledge, models, and data required for decision-making and problem-solving.

The five-database DSS structure includes user interface, text library system, method library system, model library system, and information dictionary part [26]. The function of the user interface is to understand the user’s question, to talk to the decision maker, to convert the answer into a familiar form for the user, and to explain and prove the decision-making process to the user. The functions of the text library system include information retrieval, original text storage, automatic indexing, and retrieval. The method library system centrally manages the various methods required by the model, while the model library system can support the definition of decision-making problems and model conceptualization, provide a modeling language, and create new models.

2.3.3. Features and Functions of Decision Support System. The characteristics of the decision support system include rich information sources in the database, directly facing managers, users determine the decision-making of human machines, and have the ability to assist decision-making. The decision support system mainly corresponds to semi-structured and unstructured problems [27, 28]. From the above characteristics, it can be seen that the decision support system comprehensively applies analysis technology and information retrieval technology and attaches importance to the adaptability and flexibility of the decision system corresponding to changes in the environment and user decision-making methods. This is also for noncomputer professionals. It is easy to use and can guarantee good results in decision-making.

The functions of the decision support system are as follows: First, the system collects and organizes various information and data in the decision-making process and saves them in the database. Second, the system supports various models in decision-making, organizes, and saves them. Third, you can collect, organize, and maintain method libraries and databases. Finally, after deciding on the decision-making goals, evaluate according to the existing model and provide an executable plan.

3. Experiments on Design of Brand Marketing Decision Support System

3.1. Computer Vision Technology Judges Consumer Groups

3.1.1. Face Detection. Using the Viola-Jones face detection framework to detect consumer groups, there are generally four prediction situations: the face is accurately judged as a face, and the face is misjudged as a nonface; nonhuman faces are accurately judged as nonhuman faces, and nonhuman faces are misjudged as human faces. The true case rate $T$ and the false positive case rate $F$ are introduced as measurement indicators to express the forecast. The calculation methods of these two indicators are shown in Formulas (5) and (6).

\[
T = \frac{Pt}{Pt + Nt}, \quad (5)
\]

\[
F = \frac{Pf}{Pf + Nf}. \quad (6)
\]

Among them, $Pt$ represents that a human face is accurately judged as a human face, $Nt$ represents that a nonhuman face is accurately judged as a nonhuman face, $Nf$ represents a human face is misjudged as a nonhuman face, and $Pf$ represents a nonhuman face is misjudged as a human face. The characteristics of the detector can be changed by adjusting it, and the true rate and false positive rate will affect each other.

The Viola-Jones face detection framework is tested using the FDDB dataset with difficult test data and authoritative results.

The scale of the default box of each detection convolutional layer is shown in Formula (7).

\[
S_k = S_{\min} + \frac{S_{\max} - S_{\min}}{m - 1} (k - 1), k \in [1, m]. \quad (7)
\]
At the same time, according to the previous article, the center coordinates of the default box are normalized to the range according to the feature map size of the detection layer:

\[
\begin{align*}
  w_k &= S_k \sqrt{b_t}, \quad h_k = \frac{s_k}{\sqrt{b_t}}, \\
  x &= \frac{i + 0.5}{|f_k|}, \quad y = \frac{j + 0.5}{|f_k|}.
\end{align*}
\]

The output of the border regression convolutional layer can be calculated.

\[
m \times n \times p \longrightarrow m \times n \times (4 \times k).
\]

The output size of the category prediction layer of each detection layer can be obtained by calculation.

\[
m \times n \times p \longrightarrow m \times n \times (c \times k).
\]

The overall loss function of the SSD detection network is weighted by the target location loss and the classification loss, as shown in Formula (11).

\[
L(x, c, l, g) = \frac{1}{N} (L_{\text{conf}}(x, c) + \alpha L_{\text{loc}}(x, l, g)).
\]

Calculate the following:

\[
L_{\text{conf}}(x, c) = - \sum_{i \in \text{Pos}} \sum_{j = 1}^M \sum_{i = 1}^l x_{ij} \log (c_{ij}) - \sum_{i \in \text{Neg}} \log (c_{ij}).
\]

Pos represents the default box with the label as the target, and Neg represents the default box with the label as the background:

\[
L_{\text{loc}}(x, l, g) = \sum_{i = 1}^N \sum_{j = 1}^M \sum_{i = 1}^l x_{ij}^p R(l, g_j^p),
\]

\[
l = (l_x, l_y, l_w, l_h)^T, \quad g = (g_x, g_y, g_w, g_h)^T,
\]

\[
l_x = \frac{x - x_d}{w_d}, \quad l_y = \frac{y - y_d}{h_d},
\]

\[
l_w = \log \left( \frac{w}{w_d} \right), \quad l_h = \log \left( \frac{h}{h_d} \right),
\]

\[
g_x = \frac{x^* - x_d}{w_d}, \quad g_y = \frac{y^* - y_d}{h_d}.
\]

Among them, \(x\), \(x_d\), and \(x^*\) are the test results, respectively, the abscissa of the center point of the default box, and the ground truth box, and others are similar:

\[
R(x, y) = \sum_{h = 1}^n \begin{cases} 
0.5 \times (x_i - y_i)^2, & |x_i - y_i| < 1, \\
| |x_i - y_i| - 0.5, \quad \text{otherwise},
\end{cases}
\]

\[
g_w = \log \left( \frac{w^*}{w_d} \right), \quad g_h = \log \left( \frac{h^*}{h_d} \right).
\]

In summary, the algorithm is simplified and the experiment is started.

3.1.2. Gender Judgment and Age Estimation. Combine gender judgment and age estimation into one problem, taking into account gender and age group. The classic convolutional neural network model AlexNet is used to train and verify on a simple CAS-PEAL dataset and then experiment with about 110,000 face data in the IMDB-WIKI dataset.
| Network layer      | Output        | DenseNet-121 | DenseNet-169 | DenseNet-201 | DenseNet-264 |
|-------------------|---------------|--------------|--------------|--------------|--------------|
| Conv1             | 112 × 112     |              |              |              |              |
| Pool1             | 56 × 56       |              |              |              |              |
| Dense block1      | 56 × 56       |              |              |              |              |
| Transition layer1 | 28 × 28       |              |              |              |              |
| Dense block2      | 28 × 28       |              |              |              |              |
| Transition layer2 | 14 × 14       |              |              |              |              |
| Dense block3      | 14 × 14       |              |              |              |              |
| Transition layer3 | 7 × 7         |              |              |              |              |
| Dense block4      | 7 × 7         |              |              |              |              |
| Classification    | 1 × 1         |              |              |              |              |

**Table 2: DenseNet network structure.**

- **Conv1:** Kernel size = 7 × 7, stride = 2
- **Pool1:** Max pooling window size = 3 × 3, stride = 2
- **Dense block1:**
  - Conv1 × 1
  - Conv3 × 3
  × 6
- **Transition layer1:**
  - Conv1 × 1
- **Dense block2:**
  - Conv1 × 1
  - Conv3 × 3
  × 12
- **Transition layer2:**
  - Conv1 × 1
- **Dense block3:**
  - Conv1 × 1
  - Conv3 × 3
  × 24
  - Conv1 × 1
  - Conv3 × 3
  × 32
  × 48
- **Transition layer3:**
  - Conv1 × 1
- **Dense block4:**
  - Conv1 × 1
  - Conv3 × 3
  × 16
  - Conv1 × 1
  - Conv3 × 3
  × 32
  × 48
- **Classification:**
  - 7 × 7 global average pool
  - 1000-d Fc softmax
3.2. Master-Slave Parallel Algorithm Design. Taking genetic algorithm as the basic algorithm form, the outermost structure of genetic algorithm is pure serial, and there is potential parallelism at the internal level. For example, when calculating the fitness value of the offspring, each individual in the group can be evaluated individually. In other words, there is no need for communication between evaluation processes. Therefore, from the viewpoint of reducing the amount of communication, local operations such as adaptability evaluation are handed over to the slave processor network for parallel execution, and global operations such as selection and mixing are handed over to the main processor for serial execution. It is through the comparison of running time, to test the performance of parallel algorithms. In order to solve specific mathematical problems, the execution time used in parallel computing includes the serial time, parallel execution time, communication time, and synchronization time of each processor.

3.3. Brand Marketing Decision Support System Design. The system includes a database, model library, method library, and knowledge base to analyze the relevant data of the L brand. The functional structure of the system is divided into three parts, namely, customer market analysis, performance evaluation, and demand forecasting. After analyzing the functional modules, the decision-making information and knowledge are obtained, and the decision-making plan is output.

3.3.1. Customer Market Analysis Module Design. Using the RFM model, customers are scored based on the most recent consumption, consumption frequency, and consumption amount to analyze the value of customers. Customers who have recently made purchases will have a newer impression of the brand, will most likely become repeat customers to make purchases again, and will also respond to new products. Customers with high consumption frequency have higher satisfaction and loyalty to the brand. The higher the consumption amount of customers will bring higher sales and profits, so maintenance is required.

The L brand marketing decision support system needs to research market trends, product life cycles, and positioning based on relevant data. The marketing decision support system also needs to analyze the competitive advantages, disadvantages, opportunities, and threats of the L brand according to the SWOT principle and understand the target market.

3.3.2. Performance Evaluation Module Design. Marketing performance evaluation will be transformed into return on investment, return on assets, and shareholder value. Therefore, it is necessary to conduct a comprehensive evaluation to find out the problems in time and correct them to achieve the best performance. The marketing of the L brand involves Internet marketing and offline marketing. The performance evaluation indicators of Internet marketing are the cost and click-through rate of clicks, the reach rate of reaching the designated page after clicking, and the advertising conversion rate. The performance evaluation indicators of offline marketing are the scale of coverage, the frequency of contact, and the gross evaluation point value.

3.3.3. Design of Demand Forecasting Module. The demand forecasting module adopts a time series analysis method. The sales volume of L brand products will fluctuate with seasonal changes, because the sales volume can be regarded as a function of changes over time for analysis and calculation. Select the historical sales data of the L brand, use the ARIMA model to obtain the linear prediction results, and then use the BP neural network algorithm to calculate the nonlinear prediction results.

Preprocessing the sample data and transforming it into a smooth time series by difference are firstly needed in establishing an ARIMA model. Then, determine the order of the model and check whether the error of the model meets

| Net module       | Person AP(test on 2019) | FPS(tested on 2020) |
|------------------|-------------------------|---------------------|
| FasterRCNN       | 79.6(trained on 07++12) | 7(trained on 07+12)  |
| SSD512           | 83.3(trained on 07++12) | 19(trained on 07+12) |
| YOLOv 544*544    | 81.3(trained on 07++12) | 40(trained on 07+12) |
| RFCN             | 84.4(trained on 07++12) | 11(trained on 07+12) |
| DSSD513          | 86.4(trained on 07++12) | 5.5(trained on 07+12) |

| Convolutional layer | Conv4_3 | Fc7 | Conv6_2 | Conv7_2 | Conv8_2 | Conv9_2 | Conv10_2 |
|---------------------|---------|-----|---------|---------|---------|---------|----------|
| Size                | 64×64   | 32×32 | 16×16   | 8×8     | 4×4     | 2×2     | 1×1      |

| Detection layer     | Default box size (Minimize size, Maximize size) |
|---------------------|-----------------------------------------------|
| Conv4_3             | 17.92, 35.84, 35.84, 76.8                     |
| Fc7                 | 7.68, 153.6                                   |
| Conv6_2             | 153.6, 230.4                                  |
| Conv7_2             | 230.4, 307.2                                  |
| Conv8_2             | 307.2, 384.0                                  |
| Conv9_2             | 384.0, 460.8                                  |
| Conv10_2            | 460.8, 537.6                                  |
4. Discussion on Application of Brand Marketing Decision Support System

4.1. Computer Vision Inspection Results

4.1.1. Face Detection Results. Adjust the threshold of the Viola-Jones face detection framework to obtain a series of true rate and false positive rate, and then, use the true rate as the ordinate and the false positive rate as the abscissa to obtain the corresponding ROC curve, as shown in Figure 4.

As shown in Figure 4, the ROC curve of the Viola-Jones face detection framework is closer to the upper left corner of the coordinates, which indicates that the detection framework has better performance and can detect faces more accurately.

4.1.2. Results of Gender Judgment and Age Estimation. When performing gender judgment alone, after 450 iterations of the AlexNet model, its verification set loss is stable at 0.15, and the conversion accuracy is stable at 95.8%. When performing age estimation alone, after 450 iterations, the verification set loss is stable at 1.7, and the conversion accuracy rate is stable at 40%. The confusion matrix is calculated through the classification results of the statistical verification set, and its confidence probability is 93%. In order to reduce the overall amount of computation and improve real-time performance, this study combines gender and age groups and divides training samples and verification samples into 12 categories.

As shown in Figure 5, in this sample, the largest proportion of the training sample set is males aged 30-39, and the number is 12,938, accounting for 15.11% of the training set. The least proportion of women over 60 years old is 1493, accounting for only 1.74%. In the verification set, the largest number of men was 30-39 years old, with a number of 4235, accounting for 14.87%; the least proportion of men was 19 years old or less, with a number of 464, accounting for 1.63%. The process of network training on the verification sample set is as follows:

As shown in Figure 6, after 500 iterations, the verification set loss of the network stabilizes at 1.8, and the accuracy of the verification set stabilizes at 37%. This value is similar to the product of the accuracy of gender judgment and age estimation alone. This shows that the classification model combined with gender judgment and age estimation can complete two tasks at the same time, and its classification accuracy will not be greatly affected.

4.2. Performance Analysis of Parallel Algorithms. Analyze the performance of the parallel algorithm of genetic algorithm, the initial point of the serial algorithm, and the parallel algorithm the same, run, and compare the running time. And to calculate the speedup, the running time of the parallel algorithm and the serial algorithm can be divided.

As shown in Table 1, when the initial points are the same, the running time of serial genetic algorithms and parallel genetic algorithms are quite different. The speedup ratio is between 1.8 and 9, which shows that the running time of parallel genetic algorithm is 1.8 times faster than serial genetic algorithm at the lowest and 9 times faster at the highest. Parallel algorithm has better performance.

4.3. Application Evaluation of Brand Marketing Decision Support System. According to the sales forecasting module, short-term customer needs and sales can be predicted, and production and marketing decisions can be made based on the forecast results. Using the sales data of the L brand in 2018 to predict its 2019 data and comparing the error between the predicted data and the actual data, the results are as follows:

As shown in Figure 7, when using 2018 data to predict 2019 data, the error is controlled within a very small range, with a minimum error of 0.17% and a maximum error of 2%. This shows that the system can accurately predict future data based on data from previous years. It can improve the accuracy of decision-making in production and operation plans, save costs, and reduce inventory pressure. Table 2 is the DenseNet network structure.

An accuracy rate of 86.4% was achieved on the VOC2019 test set, as shown in Table 3.

The feature map size of the SSD detection convolutional layer is shown in Table 4.

The default box size of each detection layer is shown in Table 5.

The experimental results of using different basic networks on the Caltech dataset are shown in Table 6.

Analysis of the experimental results found that the detection framework based on DenseNet has the highest accuracy, and the missed detection rate on the Caltech test set can reach 60.97%, which is 2.74% lower than VGGNet and 2.43% lower than ResNet. Although the detection speed of the network based on DenseNet is slower, compared with VGGNet and
ResNet, the detection speed is not much different. Therefore, this paper finally adopts the pedestrian detection framework Dense-SSD-FPN-Ped based on DenseNet, and the detection speed can reach 9 frames per second.

The comprehensive performance comparison table of several algorithms is shown in Tables 7 and 8.

The population statistics dataset is shown in Table 9.

5. Conclusions

There are rich information sources in the database of the decision support system. The system is directly oriented to managers, users can make decisions of human machines, and the system can assist decision-making, mainly corresponding to semistructured and unstructured problems. The decision support system can collect various information and data in the decision-making process, support various models, collect, arrange, and maintain method libraries and databases, evaluate existing models, and provide executable plans. For enterprises, a scientific and accurate decision support system can save costs, reduce inventory pressure, and bring higher profits and brand effects.

Based on the Viola-Jones face detection framework and the classic convolutional neural network, model AlexNet can accurately analyze the characteristics of consumer groups. And the accuracy of the model is high and the performance is good. Parallel genetic algorithm can improve the running speed of the algorithm and save calculation time. The brand marketing decision support system established based on computer vision technology and parallel computing can analyze the customer groups and market positioning of the L brand, evaluate sales performance, predict sales demand, and provide support for managers’ decision-making.

The decision support system is a complex system. Due to limited time and knowledge, this article only analyzes and studies the three aspects of customer market analysis, performance evaluation, and demand forecasting. There are also decision-making modules such as financial and business-related laws that are also very important and should be paid attention to in future research.

| Training network name               | Basic learning rate | Learning rate adjustment step | GPU               |
|-------------------------------------|---------------------|------------------------------|-------------------|
| Original-SSD                        | 0.001               | 80000/120000/160000          | GeForce GTX 1060  |
| SSD-Ped                             | 0.001               | 80000/120000/160000          | GeForce GTX 1060  |
| SSD-FPN-Ped                         | 0.0001              | 80000/120000/160000          | GeForce GTX 1060  |
| SSD-FPN-Ped+passthrough             | 0.0001              | 80000/120000/160000          | GeForce GTX 1060  |
| ResNet-SSD-FPN-Ped+passthrough      | 0.0001              | 100000/150000/200000         | NVIDIA TITAN X    |
| Dense-SSD-FPN-Ped+passthrough       | 0.0001              | 100000/150000/200000         | NVIDIA TITAN X    |

| Algorithm                          | Average MR in all of Caltech test | Algorithm structure                   | Hardware service | FPS  |
|------------------------------------|-----------------------------------|--------------------------------------|------------------|------|
| Dense-SSD-FPN-Ped                  | 60.97%                            | Single step detection                | GeForce GTX 1060 | 9.09 |
| RPN+BF                             | 64.66%                            | Two-step detection                   | Tesla K40        | 2    |
| CompACT-Deep                       | 64.44%                            | Two-step detection                   | Tesla K40        | 2    |
| F-DNN                              | 50.55%                            | Two-step detection                   | NVIDIA TITAN X   | 6.25 |
| F-DNN+SS                           | 50.29%                            | Two-step detection+segmentation      | NVIDIA TITAN X   | 0.40 |

| Dataset                            | Number of samples | Resolution | Minimum number of people | Maximum number of people | Average number of people | Total number of people in the database |
|------------------------------------|-------------------|------------|--------------------------|--------------------------|--------------------------|----------------------------------------|
| UCSD                               | 2000              | 158*238    | 11                       | 46                       | 24.9                      | 49885                                  |
| UCF_CC_50                          | 50                | Cannot confirm | 94                       | 4543                     | 1279.5                    | 63974                                  |
| WorldExpo’50                      | 3980              | 576*720    | 1                        | 253                      | 50.2                      | 199923                                 |
| Shanghaitech PartA                 | 482               | Cannot confirm | 33                       | 3139                     | 501.4                     | 241677                                 |
| Shanghaitech PartB                 | 716               | 768*1024   | 9                        | 578                      | 123.6                     | 88488                                  |
Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Authors’ Contributions

Yishu Liu and Jun Li contributed equally to this work as co-first author.

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