New Retail Model Based on Population Density Detection

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Abstract. With the popularization of computer technology, the transformation of business models has gradually become one of the main influencing products of computer technology development. The emergence of the “new retail” model means that the traditional retail model has become less and less suitable for the current commercial market. This paper combines the current cutting-edge methods of deep learning in the field of computer vision to optimize the traditional retail model and propose a new retail model. This model can effectively solve the problem of poor human resources in the traditional retail model. Moreover, the new retail model can apply relevant technologies such as MCNN to count relevant important business indexes such as population density, and can also be used for security inspection and intelligent queuing.

1. Introductions

"New Retail" is to encourage relevant enterprises to combine online, offline and mobile channels, and to promote the comprehensive transformation of price consumption to value consumption by the three parties [1]. This evolution of the retail model involves not only the transformation of the consumer's consumption philosophy, but also the innovative changes in traditional retail behavior. Replacing retail formats and supply chains with "new technologies" such as big data and artificial intelligence. Promote physical retail transformation and upgrading with Internet thinking, and improve circulation efficiency and service level with the support of "new logistics".

Many stores use banquets and POS machines to count customer traffic. No matter which method has certain limitations on statistical accuracy. Different from the traditional method of customer traffic statistics, this paper proposes to use the camera of the merchant to implement the statistics and diversion of passenger traffic based on the deep learning method of crowd density detection to improve operational efficiency. By means of the flow data of the queued cashier area, the convolutional neural network is used to realize the reasonable distribution of human flow, and at the same time eliminate the safety hazard caused by crowding when the customer queues.

2. Background

2.1. The definition of "new retail"
Ma Yun, Chairman of the Board of Directors of Ali Group, believes that the future will be a “new retail” model combining offline, online and logistics. As shown in Figure 1, only the offline, online, and logistics are truly combined to truly create a "new retail." This article collects other definitions of "new retail", and some scholars have defined the concept of "new retail" from different perspectives. Wang Baoyi proposed in 2017 that “new retail” is the return of the essence of retail. It is a comprehensive retail format that better meets the needs of consumers for shopping, entertainment and social multi-dimensional integration in the era of data-driven and consumption upgrades [2]. This is also the first time the industry has proposed to change the concept of logistics to Omni-channel, which has expanded the consumer's shopping model. At the same time, Zhao Shumei proposed in 2017 that “new retail” means that enterprises apply advanced Internet thinking and technology, improve and innovate traditional retail methods, and sell goods and services to final consumers under the guidance of the latest concepts and thinking. The general term for all activities [3]. This definition leads to the concept of “Internet +” and proposes the use of technology to develop a “new retail” model.

2.2. The definition of "Omni-channel"
The core of "Omni-channel" is to break the original model of relying solely on offline channels, and to extend and expand the marketing channels of retail enterprises through online and mobile channels, thereby relieving the disadvantages of offline channels in terms of time, space and price. “Omni-channel” has the following main features, as shown in Table 1.

| All Process | All Aspect | Both Online and offline |
|-------------|------------|------------------------|
| From the time of contacting a brand to the final purchase, consumers often include searching, comparing, placing orders, experiencing and sharing. Retailers must maintain full and zero-distance contact with consumers at these key nodes. | The enterprise tracks and accumulates the data of the whole process of consumer shopping, and interacts with consumers in the process in time to grasp the decision-making changes of consumers in the purchase process and provide personalized suggestions to consumers. | The development of retail channels can be roughly divided into single channel era (single channel), decentralized channel era (multi-channel), virtual and real interweaving channel era (cross-channel) and online and offline full coverage era (Omni-channel). |

2.3. The combination of artificial intelligence and new retail
The essence of the new retail is to reconstruct the "people-goods-field", in which "people" is an important part, we often think of "consumers", "thousands people have thousands ideas" and "consumer
experience" and other factors. But we ignored an important factor named "person", also means human traffic. Whether it is Internet technology or the Internet of Things, Big Data, Artificial Intelligence Technology in the retail industry, the ultimate goal is providing consumers with a better experience. This paper collects and summarizes the methods of population density detection proposed by the top conferences in recent years. At the same time, the crowd density detection algorithm which is most suitable for the new retail model is summarized, and the algorithm is used to realize the function of human flow grooming and improve the efficiency of the cashier area.

3. Architecture.
In this part, a convolutional neural network is used to analyze the crowd count. This paper mainly introduces the algorithm structure and application scenario of the convolution neural network. Retail scenes are often faced with large crowd density irregular passenger flow and so on. Convolutional neural network can be used to process the video image frame captured by the camera in order to control the flow of people.

3.1. Introduction of Convolutional Neural Network.
Convolutional neural network is one of the most commonly used network structures to solve computer vision problems in the field of deep learning of artificial intelligence [4]. The application of convolutional neural network is mainly based on the structure of the specific neural current generated for the edge of a specific input image in biological vision. The structure of CNN is mainly composed of convolution layer, pool layer and output layer. CNN is an algorithm structure with obvious hierarchical structure. The input of the former layer in CNN is usually the linear output of the next layer. This ensures that CNN can transmit better image features without loss. This article introduces CNN here in order to process image information more easily and effectively.

3.2. Algorithm Structure of MCNN.
This article will mainly take Multi-Column Convolutional Neural Network (MCNN) as an example to expand the introduction [5]. The main purpose of MCNN is to solve the problem of crowd flow and crowd count. In this situation, because of crowd occlusion and other problems, the general simple convolution neural network cannot effectively process and count the collected images. Therefore, it is the first time to apply the concept of density map to the statistics of human flow in MCNN. In MCNN, the captured video frames are mapped to the density map, and then the density map is integrated to estimate the number of people. Formula 1 shows how to map the labeled human head to a density map.

\[ H(x) = \sum_{i=1}^{N} \delta(x - x_i) \]  

Where \( x_i \) represents the pixel where the head is located, the impact function \( \delta(x - x_i) \) is used to represent the pixel, and \( N \) represents the number of heads marked.

To accommodate image frame input of various sizes, MCNN also uses a multi-channel network structure, as shown in figure 2 below [5]. The general convolution neural network will add the full connection layer in the network output layer, so it is convenient to use SVM or Softmax activation function to extract the feature vector [6]. However, because the full connection layer can only handle input of a fixed size, this limits the image size of the convolutional layer input. So MCNN gave up the full connection layer and adopted a convolution layer of 1×1 in which the feature map was mapped to the density map.
As you can see, MCNN uses a three-channel convolution layer, each of which uses convolution kernels of different sizes to handle head and image input of different sizes.

4. Discussion of Application

4.1. Analysis of traditional Retail Model
In the traditional retail model, more attention is paid to the use of human resources. A lot of statistics such as human flow, population density, etc. are all calculated by manpower. This will undoubtedly consume a lot of time in terms of efficiency. Moreover, it is impossible to conduct effective statistics and analysis on a large amount of data for a long time. It will also have a certain impact on the entire retail system. This traditional retail model cannot effectively combine the new interconnected king technology.

4.2. Application of CNN in New Retail Model
We often hear news about stampedes, and there are more and more large gatherings such as concerts, press conferences, signings, parades and so on. It is very important to avoid stampedes. We can carry on the examination through the scene photograph, when discovers the crowd density to be excessively high (or the number is too many), should take measures and so on limiting, dredging [7]. Therefore, it is very important to judge the population density in the picture accurately.

The previous methods to estimate population density are global regression (global regression), LBP, etc., but the accuracy and efficiency still need to be improved. With the development of deep learning, especially convolutional neural network (CNN) as the focus of pattern recognition research in recent years, more and more attention has been paid to it. Due to the introduction of CNN, the accuracy and efficiency of population density research have been greatly improved. Especially in the construction of the new retail model, it is very important to grasp the flow of people and the density of the crowd. CNN can help the model monitor the crowd flow in the new retail model. At the same time can also be used to monitor the safety of retail monitoring and other aspects.

5. Conclusion
This paper first analyzed the trend of the transition from the traditional retail industry to the new retail. According to the definitions proposed by different experts, this paper made a comprehensive analysis.
“New retail” refers to the application of advanced Internet thinking and technology, the improvement and innovation of traditional retail methods, and the comprehensive retail format that better meets the needs of consumers for shopping, entertainment and social multi-dimensional integration in the form of Omni-channel and pan-retail. According to this definition, this paper aims to integrate the Deep Learning - Multi-Column Convolutional Neural Network (MCNN) into the retail model to achieve statistics and drainage of people flow in the cashier area of large retailers. Finally, the application of other similar population density detection models in this scenario was compared to obtain the optimal new retail model.

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