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PRICE IMPROVEMENT USING FACIAL RECOGNITION SYSTEM

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This study aims to explore how pricing can be optimized using artificial intelligence techniques, including machine learning and deep learning.

Traditional methods of setting price for goods and services are some of the main methods that organizations have relied on for long time. The most notably method is cost-based pricing, where the price is calculated by adding direct and indirect costs and adding a specific profit margin that ensures sufficient returns for the organization. Competition-based pricing is also used, where the price is determined based on market and competitor prices without placing significant emphasis on actual costs. This is appropriate in markets characterized by product convergence and multiple competitors. Another traditional method is perceived value-based pricing, which relies on the customer's assessment of the value of a product or service. Psychological pricing is used, where product pricing is based on methods that influence consumer perceptions. Traditional methods also include promotional pricing, which is used for temporary offers to stimulate demand, especially during recessions or when launching new products. Geographic pricing, which takes into account differences in costs, taxes, and market conditions across different geographic regions, allowing for flexibility in distribution and marketing. Although these methods were effective in previous periods, technological and behavioral developments is driving many organizations to adopt more sophisticated pricing methods that respond to changing market conditions.

Facial expression recognition plays an important role in several fields, among them optimizing the prices of goods and services. Facial recognition systems generally consist of three main stages: preprocessing, feature extraction, and classification.

Preprocessing is a vital step in improving face recognition performance. It involves enhancing image quality through operations like clarity adjustment, scaling, and noise removal. This step also eliminates irrelevant details (e. g., ears) and prepares the image for accurate recognition by applying techniques such as alignment, normalization, binarization, and standardization.

Feature extraction focuses on extracting key facial features — like the eyes, nose, and mouth — and their geometric arrangement to classify expressions. Each face has a distinct structure that enables recognition. Techniques such as eigenfaces and scale-invariant feature transform are used for accurate feature extraction. Facial emotions are conveyed through the activation of specific muscle groups, revealing complex information about a person's mental state. Machine learning and deep learning techniques are used to recognize and classify these expressions by training models on labeled facial images.

The goal of price optimization is to find the best pricing strategy that leads to setting the appropriate price, maximizing profit, and meeting customer needs. This can be achieved by relying on customer behavior through facial expressions, as the face is a key feature in expressing emotions. By analyzing customer facial expressions relative to the prices of goods and services offered in retail stores (supermarkets), the store owners understand better the customer reactions to prices.

The results of analyzing customer facial expressions, both positive and negative (such as happiness, sadness, anger, surprise, fear, and disgust), provide store owners with accurate insights into customers» emotional feelings as they interact with products or services. These analysis enable store owners to precisely meet customer needs, design personalized offers and services, and enhance the shopping experience. This, in turn, leads to increased sales, builds trust between the store and customers, enhances customer loyalty and satisfaction, and increases profits. It also enables store owners to make accurate decisions based on available data, creating a competitive advantage in a market characterized by constantly changing customer tastes.

Keywords: price improvement, artificial intelligence, customers facial expressions.

СОВЕРШЕНСТВОВАНИЕ ЦЕНООБРАЗОВАНИЯ ТОВАРОВ И УСЛУГ С ПОМОЩЬЮ РАСПОЗНАВАНИЯ ЛИЦ

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Цель данного исследования заключается в изучении того, как можно оптимизировать ценообразование с помощью методов искусственного интеллекта, включая машинное обучение и глубокое обучение.

Традиционные методы установления цен на товары и услуги являются одними из основных методов, на которые организации полагались в течение длительного времени. Наиболее заметным из них является ценообразование на основе издержек, когда цена рассчитывается путем сложения прямых и косвенных издержек и добавления определенной маржи прибыли, которая обеспечивает достаточную выгоду для организации. Используется такой метод как ценообразование на основе конкуренции, когда цена определяется на основе рыночных и конкурентных цен без значительного внимания к фактическим издержкам. Это уместно на рынках, характеризующихся разнообразием продукции и множеством конкурентов. Психологическое ценообразование используется в тех случаях, когда цена на продукцию основана на методах, которые влияют на восприятие потребителя. Традиционными также являются методы, основанные на поощрительных ценах, которые используются для временных предложений с целью стимулирования спроса, особенно в периоды рецессии или запуска/выпуска новых продуктов. Географическое ценообразование учитывает разницу в ценах, налогах и условиях в разных географических регионах, что обеспечивает гибкость в дистрибуции и маркетинге. Хотя все эти методы были эффективны в предыдущие периоды, технологические и поведенческие изменения побуждают многие организации использовать более сложные методы ценообразования, которые реагируют на меняющиеся рыночные условия.

Распознавание выражения лица играет важную роль в нескольких областях, одной из них является оптимизация цен на товары и услуги. Обычно системы распознавания лиц выполняют три главных этапа: обработка изображения, извлечение признаков и классификация.

Предварительная обработка является исходным шагом в повышении эффективности распознавания лиц. Качественное изображение достигается путем настройки четкости и изменения масштаба, а также удаления шума. Изображение последовательно избавляется от ненужных деталей, таких как уши, и готовится к точному распознаванию путем изображения, выравнивания, нормализации, бинаризации и стандартизации. Извлечение признаков фокусируется на ключевых чертах лица, таких как глаза, нос и рот, и их геометрическом расположении для классификации выражений. Все лица имеют уникальную структуру, которая позволяет их распознавать. Точные методы извлечения признаков, такие как eigenfaces и масштабно-инвариантное преобразование признаков, также применяются. Эмоции на лице передаются на основе активизации определенных групп мышц и, таким образом, содержат сложную информацию о психическом состоянии человека. Машинное и глубокое обучение используются для распознавания и классификации этих выражений путем обучения моделей на маркированных изображениях.

Целью оптимизации является поиск лучшей ценовой стратегии, которая ведет к установлению такой цены, которая максимизирует прибыль при удовлетворении потребностей клиентов. Лицо является основным инструментом выражения эмоций, и, вероятно, поведение клиентов можно учесть во многих случаях, основываясь на выражениях лиц. Анализируя их, владельцы магазинов смогут лучше понимать, как клиенты отреагируют на цены товаров и услуг, предлагаемые в розничных точках продажи.

Результаты анализа выражений лиц покупателей, как положительных, так и отрицательных (таких как счастье, грусть, гнев, удивление, страх и отвращение), дают владельцам магазинов представление о чувствах и эмоциях покупателей при их взаимодействии с товарами и услугами. Результаты такого анализа позволяют владельцам магазинов точно удовлетворять потребности клиентов, разрабатывать персонализированные предложения и услуги, а также совершенствовать процесс совершения покупок. Это, в свою очередь, ведет к увеличению продаж, укреплению доверия между магазином и покупателями, повышению лояльности покупателей и увеличению прибыли. Это также позволяет владельцам магазинов принимать точные решения на основе доступных данных, создавая конкурентные преимущества на рынке, харктеризующемся постоянно меняющимися вкусами покупателей.

Ключевые слова: совершеноствование ценообразования, искусственный интеллект, выражения лиц клиентов.

Introduction. Artificial intelligence can play a crucial role in improving pricing based on the analysis of customer behavior via machine learning and deep learning techniques. It aids in comprehension of customers emotion and as a result, the price of different products and services can be optimized.

The objective of price optimization is to determine the best pricing strategy that, in turn, results in the appropriate price and maximizes profit.

This can be achieved by using the customer facial expressions, which provide vital information about emotions, since the face is a crucial feature in expressing emotions. Also provided is a facial recognition apparatus which recognizes the customer's facial expression.

The research problem can be stated as follows: How does the use of facial recognition system contribute to improving prices?

The present study aims to use artificial intelligence in the field of marketing through facial expression recognition to improve pricing. The importance of this study lies in determining the prices of goods and services, by setting appropriate prices that meet customer needs and achieve the seller's objectives. Furthermore, the study aims to:

— explore the extent of artificial intelligence usage in marketing;
— evaluate the suitability of price optimization using artificial intelligence;
— assist sellers in improving the pricing of products and services.

Literature Review. Mariem Slim et al (2018), introduce a novel and efficient method for evaluating the satisfaction of customers pertaining to the most relevant facial expressions. Six new features (disgust, anger, fear, sadness, happiness, and surprise) are used. Specifically, the most important emotions «happiness», «surprise» and «neutral» are distinguished. The proposed method is consistent with the camera position. Datasets are used for study and evaluation. The obtained results indicate that the proposed method achieves high recognition accuracy, which is better than the AU features of SVM or KNN [1, p. 6].

Wanghua Deng Et Ruoxue Wu (2019), proposed a DriCare system that can pick up drowsiness-related factors (such as yawn, blink, drowsiness, duration, etc.) of drivers in video image without attaching any device to the driver's body. In response to this limitation, we propose a new face tracking algorithm to ensure better tracking performance. Additionally, a new method for detecting facial regions based on 68 key points is established. These regions can then be used to evaluate condition of drivers. The system could, for example, issue a warning that a driver is fatigued by combining information from the eyes and mouth. It was shown that the developed system has an accuracy of about 92% according to the experimental results [2, p. 11].

Chirag Bera et al (2022), introduced a model to assess the public acceptance of products based on their brand by analyzing facial expressions of customers intending to purchase the product from a supermarket. In such circumstances, detecting facial expressions is crucial for product assessment. Several techniques have been suggested for classifying human emotions. Facial expression identification is made by feature point extraction based on sequential classifier which can reduce the time complexity. This product classification will assist the store owner to enhance sales while ensuring the best products are available to customers [3, p. 5].

Price is one of the most important components of the marketing mix, as it strongly and directly influences the consumer's purchasing decision due to the surrounding economic conditions [4, p. 641]. It translates the value of goods and services at a specific time and place into a monetary value based on the currency in circulation in the community [5, p. 244]. Pricing is the process of balancing the benefits obtained by the buyer or consumer with the monetary values they are willing to pay. It is a complex process associated with multiple economic and behavioral considerations [6, p. 14].

Determining the optimal price is a complex process [7, p. 726]. Price optimization refers to the process of determining an ideal pricing strategy by identifying the optimal price for a product or service in alignment with the organization's objectives. This goes beyond simply setting a price; it involves comprehensive analysis of market data, customer behavior and preferences, as well as key influencing factors such as demand levels, production costs, and competitor pricing. Quantitative analysis tools, artificial intelligence, and predictive models are often employed to support pricing decisions. The goal of price optimization is to maximize profitability while ensuring fair value for the customer, striking a balance between financial returns and customer satisfaction — ultimately enhancing the organization's competitiveness and market sustainability [8].

Technology can enhance the price optimization process through:

— Automated Data Analysis: Automated data analysis refers to the use of intelligent algorithms and artificial intelligence (AI) techniques to process and analyze data automatically, without direct human intervention. Through machine learning and deep learning, companies can handle vast amounts of pricing-related data — such

as customer behavior, market changes, and competitive activity — within a very short time compared to traditional methods.

This type of analysis enables:

- The rapid detection of patterns and trends in consumer preferences;
- A better understanding of the complex relationships between price and demand;
- The ability to predict market reactions to potential price changes.

— Dynamic pricing refers to a flexible pricing strategy that involves adjusting prices in real time in response to changing factors such as demand levels, supply volume, competitor actions, and customer behavior. Unlike traditional fixed pricing, dynamic pricing enables companies to continuously update the prices of their products or services based on prevailing market conditions, with the goal of maximizing revenue or enhancing market responsiveness.

— Price Testing and Optimization: Technology enables companies to conduct price testing and optimization experiments more efficiently and objectively compared to traditional methods. With the help of specialized software tools, organizations can test multiple price points for the same product or service across different customer segments, and measure the actual impact of each price on purchase rates, customer satisfaction, perceived product value, and overall profitability. These tools also allow for digital simulations of price changes before implementation in the real market, which helps in accurately assessing potential risks and expected returns [9].

Facial Expression Recognition System. Facial expressions reveal negative or positive emotions; the face serves as a source for conveying emotional states as it reflects personal feelings and acts as a mirror through which we sense natural reactions to what is said to a person, heard by him, or happens to him [10, p. 137].

Motion detection is one of the new areas in machine learning and is associated with recognizing human facial movements. Signals emitted from sensors are capable of detecting emotions or even identifying objects and their characteristics [11, p. 36].

After conducting numerous studies, it has been found that all facial expressions are consistent across different cultures. However, studies have focused on developing systems to recognize expressions based on six basic emotions: disgust, anger, fear, sadness, happiness, and surprise. These expressions are standardized among humans regardless of age, gender, or ethnicity [12, p. 139].

Certain areas of the face provide us with various pieces of information about specific emotions as follows [10, p. 132]:

— The lower face and eyes are the best areas for expressing happiness.
— The eyes are the clearest feature for revealing sadness.
— The eye area and lower face provide more information about surprise.
— Anger can be detected through expressions in the lower face, eyebrows, and eyes.
— The lower face is the best place to identify feelings of disgust.
— The eye area reflects fear.

The machine learning, a subset of artificial intelligence, enables computers to learn from experience without explicit programming. It identifies relationships between inputs and outputs of a problem using the data provided for each problem to address similar issues [11, p. 36].

The deep learning is a branch of machine learning techniques that uses neural networks. Currently, deep learning is the most widely used approach for applications such as object recognition, machine translation, speech recognition, image synthesis, and more [13, p. 1378].

There are many algorithms used for facial recognition, including Convolutional Neural Networks (CNN):

It is widely used in image recognition, image classification, object detection, facial recognition, and more. In CNNs, the input image passes through a series of convolutional layers, pooling layers, and fully connected layers, ultimately producing outputs that can be a simple class or a class probability that best describes the image. CNNs can learn multiple layers of feature representations from the image by applying various techniques. In this approach, the computer classifies images by searching for low-level features such as edges and curves, then builds a more abstract concept through a series of convolutional layers. CNNs provide greater accuracy and improve performance due to their unique characteristics, such as local connectivity and parameter sharing [14, p. 107]

Artificial Neural Networks (ANN):

It is one of the most important methods in artificial intelligence. Their concept revolves around simulating the human brain's ability to recognize patterns and distinguish objects using computers by following a self-learning process that occurs in the brain. This process leverages previous experiences to achieve better results in the future [15, p. 591].

Support Vector Machine (SVM):

This classifier is regarded as one of the most powerful traditional classifiers due to its mechanism,

which integrates both neural network algorithms and Radial Basis Function (RBF) algorithms to find the optimal separating hyperplane between training data. This classifier is known for its flexibility, scalability, and speed, giving it an advantage in handling various pattern recognition problems and bioinformatics. Additionally, it excels at processing data with a large number of features relative to the number of data records available [16, p. 21].

Facial Expression Recognition Stages:

The facial expression recognition system includes the following main stages (Fig 1):

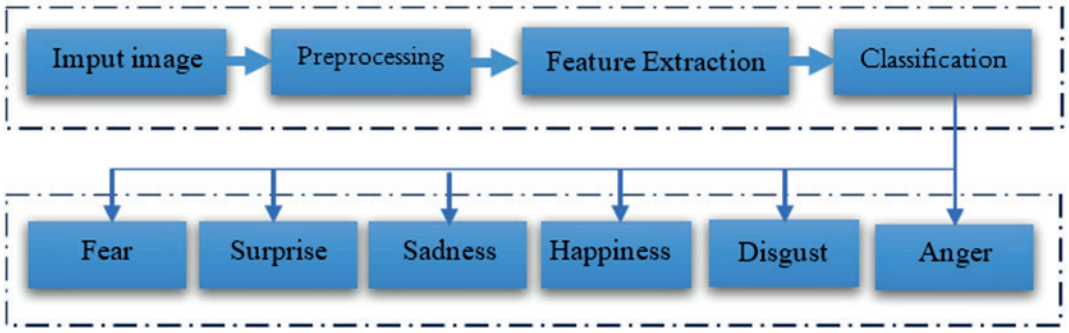

Fig. 1. Stages of Facial Expression Recognition

Facial registration is a computational technique that recognizes human faces in digital images and is used in a range of applications. Faces in the image are located using a series of prominent points known as face detection in this facial registration process. These detected faces are then geometrically aligned to match a template image [3, p. 2].

Stage 1: Preprocessing. This stage is crucial and is used to improve the performance of the face recognition system. Preprocessing of images involves various operations such as image clarity, scaling, contrast adjustment, and additional enhancement processes [17, p. 620]. It may include unwanted extra information such as the ears, neck, clothing accessories, and jewelry. Another reason for preprocessing is to enhance the quality of the captured image through different image processing methods such as alignment, normalization, standardization, and noise removal [18, p. 1670]. Noise is one of the major issues in an image, resulting from the processes of capturing, storing, or transmitting the image [12, p. 139]. These images are processed to achieve the best form suitable for recognition, including binarization (converting the image to a binary image) and noise removal [19, p. 519].

Stage 2: Feature Extraction. The primary function of this stage is to extract features from the detected face images to classify expressions. A face image represents a set of prominent features such as the mouth, nose, and eyes, along with their geometric distribution. Each face is characterized by its unique structure, size, and shape, which allows for recognition. Several techniques exist for extracting the shape of the mouth, eyes, and nose to identify the face such as eigen face, scale-invariant feature transform [20, p. 342].

Stage 3: Classification. Specific sets of unique facial muscles are activated to convey facial emotions. The signals in our expressions, which can be subtle yet complex, often carry a huge amount of information about our mental state [3, p. 3].

Machine learning techniques and deep learning neural networks allow us to recognize and analyze facial expressions (happiness, sadness, anger, surprise, fear, disgust) by training the network on expression images to classify the face's expression into a specific category.

Data analysis and price optimization. Price optimization can be enhanced by utilizing facial expression recognition through the analysis of images or videos recorded by cameras placed in strategic locations within supermarkets. These recordings capture the emotions displayed by consumers when viewing the prices of products and services, as facial expressions reflect the consumers» natural reactions to pricing.

Retailers (supermarkets) can implement a facial recognition system based on machine learning and deep learning algorithms. This system can be used to recognize consumers» facial expressions after training the neural network on a sufficient number of images depicting various facial expressions. This allows for accurate identification or detection of facial expressions and their translation as a tool for price optimization.

This approach enables the evaluation and enhancement of product and service pricing based on the results of analyzing consumers» positive and negative facial expressions (happiness, sadness, anger, surprise, fear, and disgust). This strategy helps the retailer meet consumer desires, increase sales, build trust, increase profits, enhance customer loyalty, customer satisfaction, and create a competitive advantage according to the proposed model (Fig 2).

Fig. 2. Proposed model

Conclusion. One of the biggest challenges in pricing products and services is determining the optimal price, by using machine learning and deep learning techniques. Facial expressions (customer behavior) can be relied upon to optimize prices, resulting in increased customer satisfaction and store owner profitability. Therefore, facial expressions can be used as a tool for price optimization.

This study shows that analyzing facial expressions using deep learning algorithms helps assess the customer satisfaction or dissatisfaction with prices and improve goods and services pricing.

In order to achieve this goal, it is recommended to use high-efficiency imaging devices and advanced techniques for facial extraction and also develop a specialized device to identify the number of facial expressions of customers.

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