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CONTENTS

MECHANISMS FOR FORMING AND IMPLEMENTING INVESTMENT POLICY OF COMMERCIAL BANKS... 8	Abduvaliyev Sanjar Abdurahmanovich
EVALUATION OF MANAGEMENT EFFICIENCY BASED ON BUDGETING IN ENERGY ENTERPRISES (A FACTOR ANALYSIS CASE OF "HUDUDGAZTA'MINOT" JSC)..... 17	Sobirov Shoyadbek Kurbonaliyevich
PORTFOLIO OF POSTAL SERVICES AND THE ECONOMIC EFFICIENCY OF ITS DIGITALIZATION23	Mamatkulov Gulom Rustamovich
OPTIMIZING THE BALANCE BETWEEN LIQUIDITY AND CREDIT RISKS IN ENSURING BANKING STABILITY30	Anvarov Asliddin Nabijon ugli
ECONOMIC EFFICIENCY OF RENEWABLE ENERGY DEPLOYMENT IN UZBEKISTAN.....34	Hamroyeva Sabina Ismoil qizi, Dilshod Anvarjonovich Ismailov
MODERN TRENDS AND EFFICIENCY OF LENDING TO AGRICULTURAL PRODUCERS IN UZBEKISTAN..39	Shamshetova Gulraushan Sarsenovna
ANALYSIS OF THE RELATIONSHIP BETWEEN YOUTH EMPLOYMENT AND CRIME (CASE OF UZBEKISTAN)42	Khusniddinova Gulnoza
PRIORITY DIRECTIONS FOR IMPROVING THE INFRASTRUCTURE OF UZBEKISTAN'S FINANCIAL SYSTEM47	Qobilova Nodira Qayumjon qizi, Normurodov Kh.E.
FOREIGN EXPERIENCE OF INCREASING THE EXPORT CAPACITY OF THE REGION AND SPECIFIC FEATURES OF ITS APPLICATION IN UZBEKISTAN52	Mamadzhanova Tuygunoy Akhmadzhanovna
INSTITUTIONAL APPROACH TO WASTE MANAGEMENT AND ITS ECONOMIC EFFICIENCY56	Otbosarov Abrorbek Adhamjon o'g'li
LOSS MANAGEMENT MATRIX (LOSS MANAGEMENT MATRIX) MODEL IN POWER GRID ENTERPRISES..61	Khojimurodov Zukhriddin Shukurullo oglu
MICROPROJECTS AS A MEANS OF INCREASING THE FINANCIAL ACTIVITY AND LITERACY OF THE POPULATION67	Irgashev Anvar Farxodovich
INSTITUTIONAL VA TEXNOLOGIK O'ZGARISHLAR SHAROITIDA INNOVATION BANK XIZMATLARINI JORIY ETISH METODOLOGIYASINI TAKOMILLASHTIRISH.....74	Azlarova Aziza Axrorovna
PROBLEMS OF FORMATION AND DEVELOPMENT OF REGIONAL CLUSTERS IN THE LIGHT INDUSTRY OF UZBEKISTAN80	Umarkulov Kodirjon Maxamadaminovich
DIGITAL FINANCIAL INCLUSION AS A DRIVER OF SUSTAINABLE DEVELOPMENT: EVIDENCE FROM GLOBAL TRENDS AND IMPLICATIONS FOR EMERGING ECONOMIES.....84	Sabitov Oybek Abduganievich, Sattoriy Fayzullokh Abdijabbor ugli
PROPERTIES OF HEAVY CONCRETE DISPERSEDLY REINFORCED WITH NON-METALLIC FIBERS AND SPECIFIC FEATURES OF CALCULATING CONCRETE STRUCTURES BASED ON THEM90	Usmonova Durdona, Gulomova Dilnura
THE EFFECT OF STABLE AND DYNAMIC PRICING ON CONSUMER BEHAVIOR98	Anvar DEBERDIYEV
ECONOMIC MECHANISMS FOR IMPROVING PRODUCTION EFFICIENCY IN INDUSTRIAL ENTERPRISES.. 102	M.O. Yo'ldoshova

PEDAGOGICAL EFFECTIVENESS OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN TEACHING POLITICAL SCIENCE AT HIGHER EDUCATION INSTITUTIONS	106
Rasulev Bobirjon Atkhamovich	
IMPROVING THE ORGANIZATIONAL AND ECONOMIC MECHANISM FOR REGULATING NON-STANDARD EMPLOYMENT IN THE DEVELOPMENT OF SMALL BUSINESSES	110
Fayzullayev Nurulla Bakhromovich	
PRIORITIES FOR IMPROVING THE HEALTHCARE FINANCING SYSTEM IN UZBEKISTAN	117
Gulira'no Atabekovna Ruzmetova	
FACTORS AFFECTING TAX PAYMENT SYSTEMS, EXISTING PROBLEMS, AND THEIR CAUSES	124
Tangirqulov Gulom Baxtiyorovich	
EFFECTIVENESS OF ENVIRONMENTAL TAXES IN REDUCING CARBON EMISSIONS IN UZBEKISTAN: AN ECONOMETRIC APPROACH.....	129
Kuziboev Bekhzod Hamidovich	
WAYS TO DEVELOP QUALITY MANAGEMENT IN THE SILK INDUSTRY OF UZBEKISTAN'S ECONOMY	134
Bahriddinov Asror Rakhmatovich, Boltaev Nazarbek Narzullaevich	
STATE OF LENDING TO SMALL BUSINESS PROJECTS IN COMMERCIAL BANKS AND ITS ECONOMIC- STATISTICAL ANALYSIS.....	138
Nargiza Norqobilova Abdiqodirovna	
CONCEPTUAL DIRECTIONS FOR IMPROVING THE MECHANISMS OF ENSURING FINANCIAL STABILITY IN ENTERPRISES.....	143
Asomidinova Mohigulbonu Oybek kizi	
ORGANIZATION OF MANAGEMENT ACCOUNTING IN NON-STATE HIGHER EDUCATION INSTITUTIONS	148
Xojiboyev Muxiddin Shodimuxamedovich	
THE NATURE AND ESSENCE OF DIGITAL TRANSFORMATION PROCESSES IN MASS MEDIA ORGANIZATIONS.....	151
Sharipova Shahlo Istamovna	
COMPARATIVE ANALYSIS AND EXPERIMENTAL EVALUATION OF ALGORITHMS FOR RECOVERING MISSING (NAN) VALUES IN INFORMATION SYSTEM DATA	156
Yarmatov Sherzodjon Shokir oğlu, Orifov Oxunjon Fazliddinzoda	
ANALYSIS OF THE STATE OF MARKETING MANAGEMENT IN MANUFACTURING ENTERPRISES	167
Musayeva Shoirazimovna	
IMPROVING LOAN PORTFOLIO QUALITY AND CREDIT RISK MANAGEMENT MECHANISMS	173
Turgunov Nodirbek Muminjanovich	
INNOVATION CAPABILITIES AND EXPORT PERFORMANCE: THE MEDIATING ROLES OF SUPPLY CHAIN INNOVATION AND ENTREPRENEURIAL ORIENTATION — EVIDENCE FROM UZBEKISTAN	177
Mukhammadyaminova Shakhzoda	
URBAN PLANNING OF TRANSPORT INTERCHANGE HUBS NEAR TUBERCULOSIS CARE FACILITIES IN UZBEKISTAN	183
Gabibova Irina Vagifovna, Abdumuminova Diyora Gayratovna	
ADAPTING INTERNAL AUDIT STANDARDS IN BUDGET ORGANIZATIONS TO PUBLIC PROCUREMENT PRACTICES.....	192
Meliboyev Askar Eshmuratovich	
ECONOMETRIC EVALUATION OF INVESTMENT EFFICIENCY IN KHOREZM REGION	197
Otajanov Umid Abdullayevich	
SCIENTIFIC AND PRACTICAL SIGNIFICANCE OF MODERN RECLAMATION AND GIS TECHNOLOGIES ON SALINE SOILS IN KARAKALPAKSTAN	205
Tajibaev Berdakh	
ISSUES REGARDING THE IMPLEMENTATION OF THE “TOLLING OPERATIONS” MODULE IN THE GOODS MOVEMENT MANAGEMENT SYSTEM UNDER THE CUSTOMS TERRITORY PROCESSING REGIME	212
Lutpullaev Shukrullo Kudratullaevich	

THE ROLE OF DIGITAL MARKETING IN ENHANCING TOURISM-RELATED BUSINESSES IN UZBEKISTAN Akmaljon Odilov	218
INTERNATIONAL TRENDS OF DIGITALIZATION IN CUSTOMS MANAGEMENT Radjapova Latofat Sardarovna	222
THE ROLE OF TAX POLICY IN THE TRANSITION TO A GREEN ECONOMY Dexkanova Shodiyona Kaxramon qizi	230
PRACTICES IN ENTERPRISE COST STRUCTURE MANAGEMENT AND DIRECTIONS FOR IMPROVEMENT Aymukhammedova Amina Kakajanovna	236
IMPROVING THE ECONOMIC EFFICIENCY OF CLOTHING MANUFACTURING ENTERPRISES IN UZBEKISTAN THROUGH DIGITAL TRANSFORMATION Axmedova Gaziza Azim kizi	242
RECONCEPTUALIZING BUSINESS INCUBATORS IN STARTUP ECOSYSTEMS: THEORETICAL FOUNDATIONS AND INSTITUTIONAL MECHANISMS Gafujon Usmanov	246
DEVELOPMENT OF MODERN MARKETING APPROACHES TO CUSTOMER RELATIONSHIP MANAGEMENT IN RETAIL ENTERPRISES Safarov Bakhtiyor Djurakulovich	257
MECHANISMS FOR EVALUATING AND IMPROVING THE EFFECTIVENESS OF MARKETING STRATEGIES IN THE PUBLIC TRANSPORT SECTOR Berdiyrov Temur Azamatovich	263
THE INFLUENCE OF HYDRODYNAMIC ASPECTS OF GROUNDWATER LEVEL RISE ON URBAN WATERLOGGING B.D. Abdullaev, B.R. Nasibov, Sh.T. Irgashev, D. Abdullaev	268
BASIC INFORMATION MODEL OF A DIGITAL OBJECT Gulyamov Shukhrat Mannapovich, Karakhanova Alsu Muratalievna, Keldiyorov Sirojiddin Tura ugli, Zayniddinova Zebiniso Akmalovna	277
COMPARATIVE LIFE CYCLE AND TECHNO-ECONOMIC ANALYSIS OF SOLAR PANEL MATERIALS FOR SUSTAINABLE PHOTOVOLTAIC SYSTEMS Urishev Omadjon, Kushakova Sarvinoz, Kamolboyev Sirojbek	281
PRIORITY DIRECTIONS FOR FORMING ECOLOGICALLY ORIENTED MANAGEMENT IN CONSTRUCTION INDUSTRY ENTERPRISES Kholov Hamza Tajiddinovich	294
INVESTIGATION OF GERMANIUM EXTRACTION TECHNOLOGY FROM TECHNOGENIC METALLURGICAL WASTE Yormatov Dostonbek, Shodiyev Abbos, Muhammadiyev Elbek	301
MECHANISMS FOR IMPROVING RESOURCE EFFICIENCY AND OPTIMIZING PRODUCTION COSTS IN THE CONSTRUCTION MATERIALS INDUSTRY Utbasarov Doniyorjon Bakhtiyarovich	309
THEORETICAL, PRACTICAL AND METHODOLOGICAL PROBLEMS OF AUDITING THE ACTIVITIES OF ECONOMIC ENTITIES ON THE BASIS OF INTERNATIONAL STANDARDS Mirzaeva Sabina Khushnudovna, Khaydarova Dildora Djakhongirovna	318
THE IMPACT OF DIGITAL AND INNOVATIVE TECHNOLOGIES ON WOMEN'S LABOR IN INDUSTRIAL ENTERPRISES OF UZBEKISTAN UNDER INDUSTRY 4.0 Doniyorova Zukhrabonu Alisher qizi	322
LEVEL OF ENSURING FOOD SECURITY: IMPLEMENTATION MECHANISMS AND INSTRUMENTS Sodiqjon Qodirovich Mattiyev	328
DIGITAL TRANSFORMATION, ECONOMIC EFFICIENCY, AND LOCALIZATION POLICY OF THE PUBLIC PROCUREMENT SYSTEM Turabov Sarvar Abdumalikovich	334
TA'LIM XIZMATLARI BOZORIDAGI INNOVATSIYALAR IQTISODIY XAVFSIZLIKNI TA'MINLASH VOSITASIDA Bozorova Madina Raxmat qizi	339

PROJECT-ORIENTED ESP32 IOT CURRICULUM WITH A SHARED-RESOURCE LABORATORY MODEL: DESIGN, IMPLEMENTATION, AND LESSONS LEARNED	344
Ulugbek Tursunaliyev, Lazizbek Yusupov	
FIVE-CRITERION METHODOLOGY OF INTERNAL CONTROL ENVIRONMENT ASSESSMENT IN TEXTILE INDUSTRY ENTERPRISES	353
Babakulova Matluba Kurbannazarovna	
THE EFFICIENCY OF EDUCATION-INDUSTRY INTEGRATION IN THE CONTEXT OF THE KNOWLEDGE ECONOMY.....	357
Uzaydullayev Sherzod Shukurullayevich	
MECHANISMS AND DIRECTIONS FOR DEEPENING REGIONAL INTEGRATION PROCESSES IN CENTRAL ASIA.....	361
Akbarova Kamola Akmaljonovna	
EVALUATION OF THE EFFECTIVENESS OF MANAGEMENT SYSTEMS IN HEALTHCARE INSTITUTIONS	368
Saidov Suhrob Shodmonovich	
IMPROVING INVESTMENT ATTRACTION MECHANISMS IN UZBEKISTAN'S SERVICE SECTOR: BARRIERS, OPPORTUNITIES, AND POLICY RECOMMENDATIONS.....	371
Shermatov Axror Abdixakimovich	
METHODOLOGICAL FOUNDATIONS FOR FORMING CUSTOMS RISK PROFILE INDICATORS BASED ON MATHEMATICAL AND STATISTICAL METHODS	377
Niyazov Sherzod Shovkat ugli	
AN INSTITUTIONAL GOVERNANCE FRAMEWORK FOR CRYPTO-ASSET REGULATION: ADDRESSING LEGAL UNCERTAINTY IN DIGITAL FINANCIAL SYSTEMS	385
Iminokhunov Abdukokhor A., Khakimov Abdurakhmon Mukhammad-Ali ugli	
THEORETICAL AND ORGANIZATIONAL-ECONOMIC FOUNDATIONS OF THE SERVICE SECTOR	396
Kurbanova Rahima Jamshedovna	
REGIONAL ASSESSMENT OF THE OPENNESS OF SPECIAL ECONOMIC ZONES IN UZBEKISTAN BASED ON A SYNTHETIC INDICATOR.....	401
Anvarkhonov Abdulatifkhon Jamshidkhon ugli	
IMPROVEMENT OF THE REGIONAL INVESTMENT ENVIRONMENT ASSESSMENT CRITERIA AND INDICATORS SYSTEM.....	407
Maxmudov Jasurbek Ergashevich	
ANALYSIS OF FOREIGN INVESTMENT ATTRACTION PRACTICES IN THE NATIONAL ECONOMY.....	412
Ochilov Bobur Bakhtiyor ugli	
ASSESSMENT OF SOURCES OF EQUITY FORMATION IN JOINT-STOCK COMPANIES AND THE EFFECTIVENESS OF THEIR USE.....	421
Savinova Galina Anatolevna	
DIGITAL MARKETING INTEGRATION, KPI ARCHITECTURE AND CAUSAL EVALUATION OF ENTERPRISE COMPETITIVENESS IN EMERGING MARKETS: A CONCEPTUAL-METHODOLOGICAL FRAMEWORK FOR UZBEKISTAN	429
Bakhtiyor Ruziev Eshmuminovich	
IMPROVING FOREIGN EXCHANGE RISK MANAGEMENT PRACTICES IN COMMERCIAL BANKS OF UZBEKISTAN	434
B.K. Tugalov	
CHANGES IN THE BIOLOGICAL DIVERSITY OF HOOFED ANIMALS IN THE TUGAI FORESTS OF THE SOUTHERN ARAL REGION UNDER CLIMATE CHANGE CONDITIONS.....	438
J. U. Tilepov, A. A. Jumamuratova	
ECONOMETRIC ASSESSMENT MECHANISMS OF THE IMPACT OF TRADE SERVICE QUALITY INDICATORS ON THE LEVEL OF COMPETITIVENESS	442
Toxirov Javlon Raximovich	
O'ZBEKISTONDA BIZNES MUHITINI RIVOJLANTIRISHDA XORIJIY INVESTITSİYALARNING AHAMIYATI ..	447
Xazratov Abror Panjiyevich, Muratkulov Xumoyun Dilshodovich	

LEGAL FOUNDATIONS AFFECTING THE DEVELOPMENT OF THE COTTON PROCESSING INDUSTRY IN BUSINESS ENTITIES	452
Abdullayev Hamidulla Abdug'ani o'g'li, Sayitbayev Shermirza Datkamirzayevich	
BALANCING ECONOMIC GROWTH AND ENVIRONMENTAL PROTECTION IN TOURISM	456
Kamalova Malika Umidjanovna, Zufarova Nozima Gulamiddinovna	
DEVELOPMENT OF A MODEL FOR IMPROVING FACE-ID TECHNOLOGY IN ENSURING INFORMATION SECURITY ON E-PLATFORMS.....	462
Maxamadov Rustam Xabibullayevich,Djamatov Mustafa Xatamovich	

DEVELOPMENT OF A MODEL FOR IMPROVING FACE-ID TECHNOLOGY IN ENSURING INFORMATION SECURITY ON E-PLATFORMS

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Abstract. This article analyzes modern methods and algorithms for the automatic recognition of human emotions through facial expressions. The study examines the processes of facial expression identification based on the Facial Action Coding System (FACS). The possibilities of detecting emotional states, including excitement, confusion, concentration, and nervousness, through the identification of facial landmark points and the distances between them are discussed. Furthermore, the effectiveness of using the Tree-Augmented Naive Bayes (TAN) classifier and the CK+ database in facial expression analysis is investigated.

The article also proposes a semantic model of an automated facial expression recognition system and substantiates its significance in the educational process, particularly in improving authentication and monitoring systems within electronic learning platforms. The proposed system enables continuous monitoring of students' emotional states, enhances security during examination processes, and automates personal identification procedures.

Keywords. Facial expression recognition, emotion recognition, Facial Action Coding System (FACS), Action Units (AU), facial landmarks, biometric identification, Tree-Augmented Naive Bayes (TAN) classifier, CK+ database, artificial intelligence, computer vision, human-computer interaction, e-learning, authentication, facial movement analysis, emotional state monitoring.

INTRODUCTION

Human beings extensively utilize emotions in the processes of information exchange and problem-solving. In the analysis of personal identification, facial recognition is considered one of the most successful methods. By taking human emotions into account during facial recognition, it becomes possible to facilitate interaction between humans and technologies through the development of user interfaces based on various models and algorithms. Numerous approaches have been employed to identify facial expressions and determine changes in human emotions under different conditions. In this article, we analyze effective facial expression recognition methods based on the localization of facial landmarks and the determination of distances between facial components. These methods enable the automatic identification of facial expressions by analyzing various facial movements and emotional states of a person from images or video camera inputs.

LITERATURE REVIEW

Various independent studies have investigated and compared person-dependent features and facial expression recognition methods [1]. The Tree-Augmented Naive Bayes (TAN) classifier, capable of distinguishing different facial characteristics, was introduced in [2]. Tree-Augmented Naive Bayes (TAN) is a machine learning algorithm that extends the traditional Naive Bayes classifier by incorporating a tree structure to model dependencies among features. While the Naive Bayes algorithm assumes conditional independence among features given the class label, many real-world scenarios involve interdependent features. TAN aims to capture

these dependencies more effectively while preserving the simplicity and computational efficiency of the Naive Bayes approach. By integrating a tree structure into the probabilistic model, TAN enables the representation of more complex relationships between variables while maintaining classification efficiency. In addition, integrated systems facilitating interaction between humans and machines have also been developed [3].

Using the SAMMI (Semantic Effect-Enhanced Multimedia Indexing) method, significant progress has been achieved in the recognition of human emotions [4]. Traditional multimedia indexing methods often rely on low-level features such as color, texture, and shape for content representation and retrieval. However, these approaches frequently fail to capture the rich semantic information embedded in multimedia data. Semantic Effect-Enhanced Multimedia Indexing has emerged as an innovative solution aimed at bridging the gap between content and context by incorporating semantic effects into the indexing process. Furthermore, the efficiency of several functions for neutral facial expressions has been compared, and three sets of features — coordinates, distances, and landmark points — have been extensively studied [5].

Researchers have established a framework for facial expression recognition using multimodal interfaces based on the CK+ database [6][9]. Adaptive learning processes and facial expressions were recorded through video sequences using the coding system developed by Ekman and Friesen [7]. One of the major limitations of conventional e-learning systems is the inability to adequately consider students' emotional states and provide personalized feedback based on integrated pedagogical models [8][10].

A brief overview of the CK+ database is also provided. In 2000, the Cohn-Kanade (CK) database was introduced to advance research in automatic facial expression recognition. Since then, the CK database has become one of the most widely used benchmark datasets for the development and evaluation of facial expression recognition algorithms.

Several internal emotion recognition applications can improve the performance of facial expression recognition systems. In such systems, certain emotions are often misclassified [6]. Although multiple approaches have been proposed for emotion recognition based on facial expressions, several challenges still exist due to variations in viewing conditions, as illustrated in Figure 1. Head position is generally categorized into three types:

- pitching – facial detection when the head is tilted upward or downward;
- roll – facial detection when the head is tilted sideways;
- yaw – facial detection when the head is turned to the left or right side.

Developing an automated facial expression recognition system is a highly complex process. Significant progress has been achieved in extracting various facial objects and constructing their templates using facial landmark points and the distances between them.

The Facial Action Coding System (FACS) decomposes facial expressions into Action Units (AUs), which represent the smallest visually distinguishable components of facial movements. Each AU corresponds to a specific facial muscle or a group of muscles, while combinations of AUs form the basis for describing a wide range of facial expressions. This system enables a subtle and precise analysis of facial dynamics.

Researchers Paul Ekman and Wallace V. Friesen, who conducted extensive studies in facial expression analysis, emphasized the direct relationship between facial expressions and emotional states such as happiness, confusion, concentration, and nervousness. Their experiments primarily focused on emotions including excitement, confusion, concentration, and nervousness.

Excitement State:

This emotional state is observed when facial expressions exhibit a high frequency of agitation.

Indicators: smiling with an open mouth, widened eyes, and raised eyebrows.

Confusion (Hesitation) State

This emotional state is identified through the observation of diverse facial expressions.

Indicators: raised nose and forehead, one eyebrow elevated higher than the other, and compressed lips.

Concentration State:

This state is associated with tasks requiring the individual to ignore potential environmental distractions.

Indicators: reduced blinking, fixed gaze, and slightly raised eyebrows.

Nervousness State

This emotional state is characterized by rapid facial movements associated with emotional tension (e.g., lip biting).

Indicators: neutral eyes, with one side of the lips raised and slightly pulled backward.

We focus on the functions of facial landmark points and the distances between them, as these facilitate the automatic recognition of facial expressions while considering users' emotional states, such as happiness, confusion, concentration, and nervousness. The following measurements and functions used for emotion recognition were analyzed: facial description functions, facial landmark extraction functions, and distance measurement functions between facial regions. We propose an emotion-based facial image recognition system

capable of effectively identifying emotions through the detection of specific facial landmarks and the distances among them.

Facial landmarks are defined according to the following distinctive regions:

eye region;
mouth region;
nose region;
forehead region;
and others.

To extract these characteristics, it is necessary to analyze feature sets related to landmark points and the distances between facial objects.

Landmark Feature Set:

We extract three sets of functions corresponding to characteristic landmark points that represent the average measurements of specific facial regions.

RESEARCH METHODOLOGY

Over the past decade, spontaneous facial expressions have played a significant role in recognizing human emotions. In the field of facial recognition, image analysis using various algorithms and models has attracted considerable attention from researchers as one of the most promising directions. In this process, human-computer interaction plays an essential role, where factors such as the characteristics and spatial arrangement of facial features, as well as the manifestation of emotions on the human face, are of particular importance. Over the years, various methods for facial identification have emerged. Many researchers emphasize that the most effective approaches are based on recognizing facial appearance while simultaneously identifying the internal emotional states of individuals and associating them with personal identity information.

Typically, these methods consider a range of fundamental human emotions, including excitement, happiness, hesitation, fear, concentration, nervousness, and others. Many facial expression recognition techniques rely on geometric facial features. The methods used for facial expression analysis are commonly based on the Facial Action Coding System (FACS), developed by researchers Paul Ekman and Wallace V. Friesen, in which each facial expression is represented by specific Action Units (AUs). The Facial Action Coding System (FACS) is a widely recognized and systematic approach for analyzing facial expressions. It provides a detailed and objective framework for describing facial movements and offers deeper insight into the complex language of human emotions. Facial expressions play a crucial role in human communication by conveying a wide spectrum of emotions and intentions. FACS was introduced as a tool that allows researchers and practitioners to systematically decode and categorize subtle facial movements.

ANALYSIS AND RESULTS

Distance-Based Feature Set: We further derive meaningful features from the distance-based feature set. As a result of this process, three primary distances are identified: the distance related to the eye region, the distance related to the mouth region, and the displacement movement of the head. Using the line equation between points $([x_1, x_2], [y_1, y_2])$, a line is drawn from one coordinate to another. Based on these two points, the distance L between the coordinates is calculated as follows:

$$L = \sqrt{[(x_2)^2 - (x_1)^2]} \text{ (equation) } \quad (1)$$

Analysis of the Proposed System

The operating principle of the proposed system, as illustrated in Figure 2, consists of image analysis and feature extraction based on facial landmarks and distance measurements. If facial movement is detected, the system produces an output corresponding to the identified emotional state. A more detailed explanation is provided below. In the development of the proposed system, its semantic model was designed using a branching algorithm approach (Figure 1 presents the semantic network model of the system).

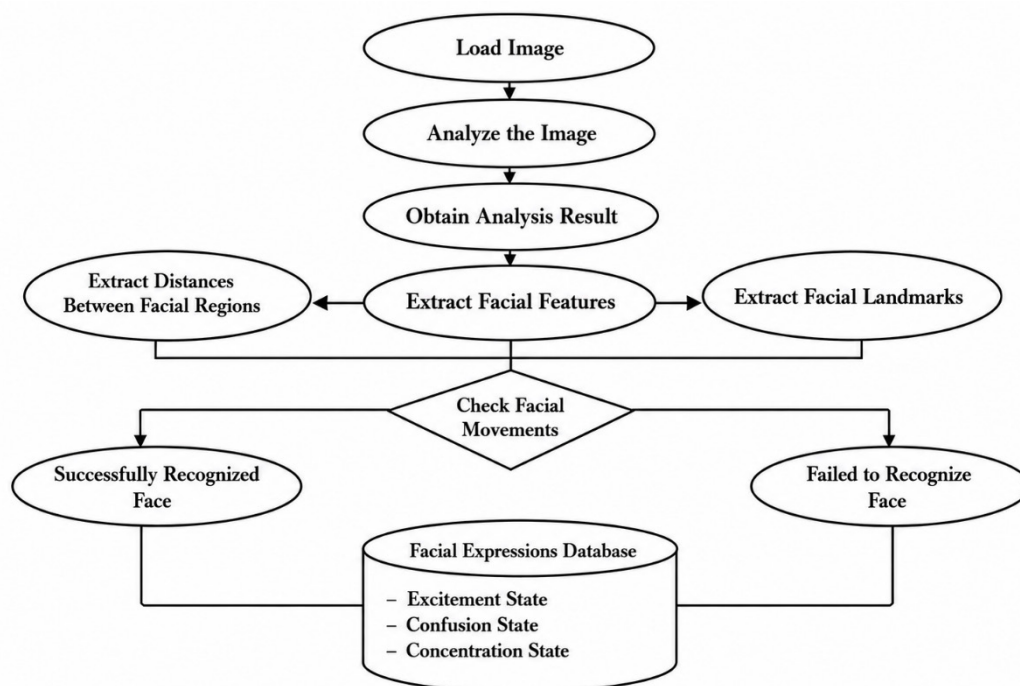


Figure 1. Semantic Network Model of the System

In the proposed system described above, an image containing the facial expression of the target individual (student, learner, or cadet) is uploaded into the system. The uploaded image is analyzed by separating it into different parameters. The emotional states of the face are examined, since the individual's face may appear in various conditions and orientations within the image.

After performing all analytical functions, the system compares the extracted facial expressions with those stored in its own database or in an integrated external database. Consequently, the system identifies the facial expression of the individual (student, learner, or cadet) appearing in the uploaded image or in front of the camera, together with all associated personal information, including full name, year of birth, nationality, and other relevant data.

Furthermore, when a user attempts to access an e-platform profile, the system automatically authenticates whether the person accessing the profile is indeed the legitimate owner. If another individual attempts unauthorized access to the profile (for example, when a different person tries to take an examination on behalf of the profile owner), the system automatically restricts access privileges and prevents unauthorized login attempts.

CONCLUSION AND SUGGESTIONS

In conclusion, the Facial Action Coding System (FACS) makes a substantial contribution to the study of facial expressions and human emotions. Its impact extends across multiple disciplines, ranging from psychology to advanced technological systems, thereby shaping our understanding of non-verbal communication. As technology continues to evolve, the use of FACS terminology and methodologies serves as a fundamental basis for further advancements in this field.

In the automatic recognition of facial expressions, it is particularly important to analyze changes in facial movements while considering students' emotional states within educational environments. The proposed system can, in the future, provide continuous monitoring of students' emotional conditions, record emotional changes through video-based data storage, and enable subsequent analysis and supervision.

To achieve this objective, it is essential to establish fully automated monitoring systems in examination centers in order to minimize the misuse of students' official identities and profiles. Such automated systems can be integrated into all educational e-platforms. In this context, the facial expression identification model proposed in this study can be effectively utilized during e-platform authentication processes, since human facial expressions vary over time depending on mood, psychological state, and internal emotional conditions.

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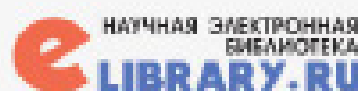
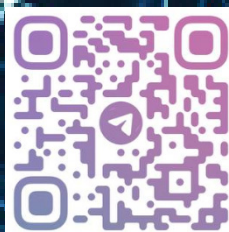
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