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Web Application Strategic Classifier Using Deep Learning for Custom Eligibility

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ABSTRACT: In a time of constant development of digital communication, traditional billboards are found to be inefficient in the provision of targeted and interactive advertisements. This article is for the setting-up and running of a Smart Billboard System that consists of the real-time age and the gender recognizing feature to alter the content. The use of deep learning models, like CNN (Convolutional Neural Networks) has been proposed to the system that can get not only the detection but also the classification of viewer differences by tracking the live camera. By means of React, TypeScript, and TailwindCSS, an online dashboard is generated for the managers to endorse ads and demographics analytics. For example, the AI model supports the age/gender recognition algorithm which is so fast that it is suitable even for small devices like NVIDIA Jetson Nano, requires minimum latency and through on-device processing of the data and a privacy of the identification. The system learns about the viewer's interests and changes the content accordingly, thus contributing to both engagement and the usefulness of the advertisements. The integration of this AI-driven web development stack constitutes an interaction.

KEYWORDS: Smart Billboard, Age Detection, Gender Recognition, CNN, ReactJS, Edge Computing, Real-Time Analytics, AI-based Advertising

I. INTRODUCTION

The prospect of the digital transformation of the public advertising sector has caused a need for further changes in the area of more interactive, intelligent, and context-aware billboard systems. In a traditional sense, billboards, whether they are static posters or digital screens, have always failed to be dynamic in terms of audience techniques. These static devices have been used to communicate the same idea to all people, regardless of whether they were of the target demographic or not. As a result, they have seen a reduction in engagement rates and an inefficient ad spend.

Artificial Intelligence (AI), computer vision, and edge computing are the driving force behind the progress in the fields of technology. As a result, we are currently witnessing the emergence of a new generation of intelligent systems that have the capability to create personalized digital experiences. In the given context, the Smart Billboard System idea is one that is based on real time age and gender detection for showing personalized advertisements. The operation of the system revolves around a live camera and CNNs to recognize the faces and to carry out the prediction of the viewer's demographic profile. The ad that is most suitable, in terms of the prediction, will change dynamically, on a digital screen. The tool is built off of a web-based dashboard which allows easy management of ad content. It also contains provisions for scheduling and is even capable of performance analytics, characteristics that enable advertisers to now be more strategic in their decisions.

The secure, modular, and real-time deployable architecture covers the whole process of being privacy-conscious, modular, deployable in real-time, and able to perform well in places such as malls, airports, and smart city installations. This merge of computer vision with dynamic ad display systems has taken the form of a leap forward in intelligent advertising. It will enable enterprises to hit their target audience more precisely and consequently pull up their ROI.

II. LITERATURE SURVEY

Application of CNNs in Gender and Age Classification

The use of Convolutional Neural Networks (CNNs) has proved to be highly accurate in facial feature analysis, especially for gender and age recognition. Scientists have used CNNs as the preferred approach to such classification problems because they can learn intricate visual patterns.

Levi and Hassner's CNN Model [1]

Levi and Hassner suggested a CNN-based system trained on the Adience dataset, which was composed of real-world, unconstrained images. Their system exhibited competitive performance both in gender and age classification to the level of existing top models.

Rothe et al.'s Work on Age Prediction [2]

Rothe et al. utilized the massive-scale IMDB-WIKI data to train deep neural networks that could predict a person's age. Their technique resulted in current best results with negligible error rates and demonstrated how massive datasets contribute to model efficacy.

Lightweight Models for Edge Devices [3]

To support real-time inference on resource-limited platforms, researchers trained lightweight CNN models using the UTKFace dataset. These models were optimized for edge devices, enabling fast and efficient demographic analysis without the need for powerful servers.

AI-Powered Advertising Kiosks [4]

One of the studies brought forth an AI-powered advertising kiosk that could recognize demographic characteristics and recommend content based on those. The system, though, had some shortcomings, including no integrated analytics dashboard and no on-device and ads-control.

Performance on Portable Devices [5]

Another research study investigated the deployment of demographic detection models on miniaturized platforms such as Raspberry Pi and NVIDIA Jetson. These deployments exhibited low-latency performance and power-efficient usage, reflecting the potential of portable AI applications.

Gap in Integrated Solutions

While advances have been made in model precision and hardware energy efficiency, most existing solutions cater to individual silos—either hardware deployment or algorithm optimization—resulting in a disintegrated system design affecting real-world efficacy.

Proposed Smart Billboard Solution

This paper fills the gap that currently exists by suggesting a Smart Billboard system with an end-to-end solution. It combines AI-driven demographic analysis with real-time ad serving, device-level management, and horizontally scalable analytics and is hence ideal for field deployment

III. METHODOLOGY

This framework brings together computer vision, deep learning, and real-time web technology to power intelligent demographic identification and targeted advertisement display. The following components elaborate on the methodology:

1. User Authentication

- An authentication mechanism is created for managing user access:
- Registration/Login System: A registration/login mechanism is implemented where users can register or login, with an easy-to-use UI that lets them toggle between the two modes.
- Data Security: User passwords are hashed and stored securely. Session tokens or cookies are employed for session management.

- This makes it possible for only authenticated users to access and manage sensitive modules like the analytics dashboard.

2. Live Camera Feed Integration

- When the user logs in, the system turns on the user's webcam using OpenCV:
- Real-time Video Capture: The system streams frames from the webcam continuously.
- Frame-by-Frame Processing: Each frame is processed to detect and process human faces.
- This live video feed is the foundation for demographic prediction.

3. Face Detection Module

- In order to extract facial areas from the video stream:
- Haar Cascade Classifier: A light-weight detector utilizing feature-based pattern recognition.
- Deep Neural Network (DNN) Face Detector: A stronger alternative trained on big data sets, providing improved accuracy in different conditions (e.g., lighting, orientation).
- Detected face areas are cropped and sent to the CNN model for analysis.

4. Dataset and Preprocessing

- The primary training dataset for the CNN is the UTKFace dataset, containing:
- More than 20,000 face images
- Annotations for:
- Age (0 to 116 years)
- Gender (Male/Female)
- Ethnicity (not used here but provided)
- Preprocessing Steps:
- Image Resizing: The images are all resized to a constant size of 200x200 pixels for uniform input.
- Normalization: The pixel intensities are scaled (usually to 0–1 range) to speed up training and enhance convergence.
- Dataset Splitting
- 80% of the dataset is utilized in training
- 20% for testing
- Optional: 10% of the training set for validation
- Such preprocessing provides data consistency and model generalization.

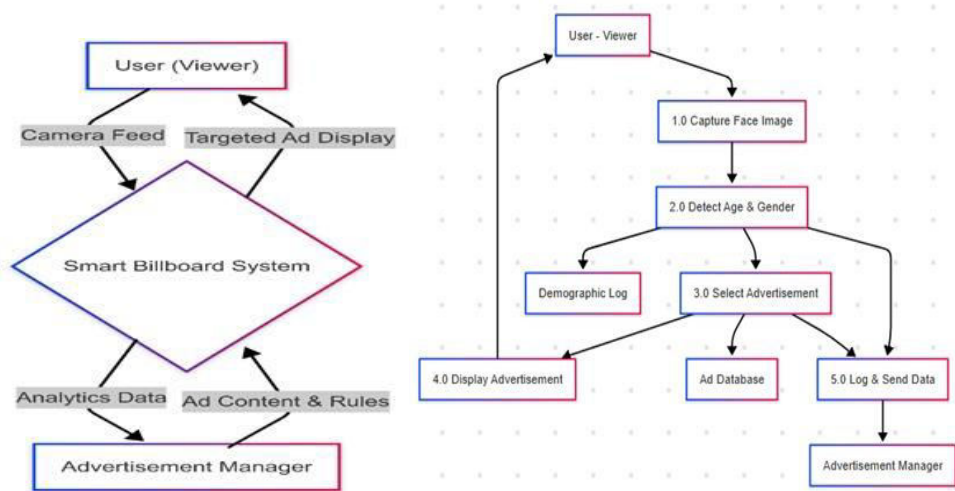
5. Age and Gender Prediction Using CNN

- The preprocessed UTKFace dataset was used to train a custom Convolutional Neural Network (CNN) to perform two tasks at once:
- Gender Classification: Predicts binary class (Male or Female)
- Age Estimation: Does regression to predict age or categorize age into pre-defined groups (e.g., Child, Young Adult, Adult, Senior)
- **Model Architecture:**
 - Input Layer: Takes a 200x200x3 RGB image.
- **Convolutional Layers:**
 - Multiple convolutional layers with increasing filter depths (e.g., 32, 64, 128)
 - Kernel size typically 3x3
 - Activation: ReLU
- **Max-Pooling Layers:**
 - Follows each convolutional block
 - Reduces feature map dimensions, preserving dominant features and reducing computation
- **Flatten Layer:** Converts 2D feature maps into a 1D vector.

6. Smart Interface and Analytics Dashboard

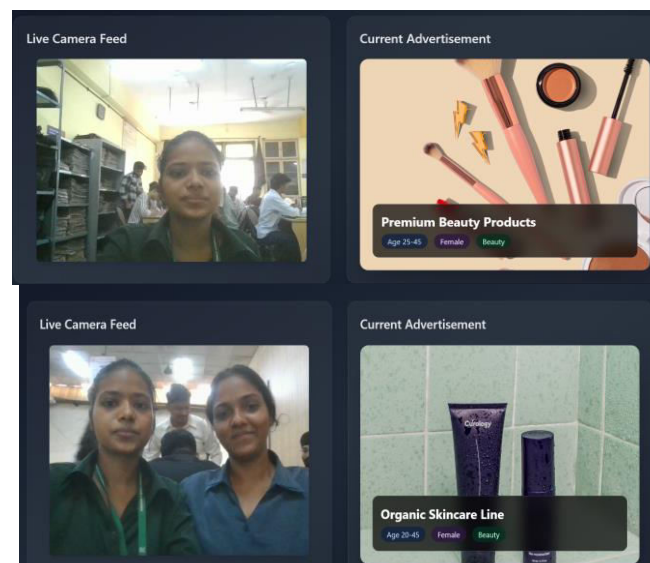
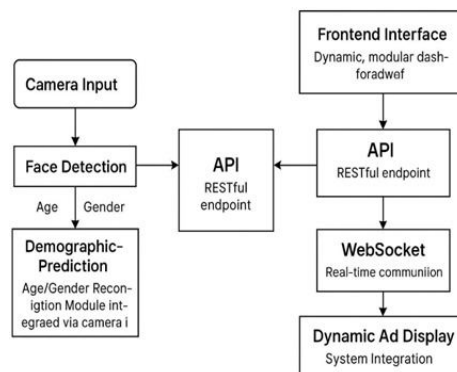
- A ReactJS-based frontend displays real-time, demographic-targeted ads with a clean, responsive design.
- An admin dashboard tracks viewer stats, ad impressions, and trends, using visual charts for easy analysis.

IV. FIGURES AND RESULTS



DFD LEVEL 0

DFD LEVEL 1



V. CONCLUSION

The Smart Billboard System is a significant stride in the direction of modernizing conventional advertising mode through the usage of the state-of-the-art web technologies and artificial intelligence. A React-based modular frontend along with the age and gender recognition module at the backend makes the system versatile and adaptable, allowing it to represent the dynamic data on the electronic display.

With the use of React, Vite, and TailwindCSS for rapid prototyping, as well as the development of edge AI with the use of machine learning models for real-time detection of people's demographic parameters, the proposed project effectively integrates interactivity and personalization. Such a combination results in an increase in user engagement and allows advertisers to have a stronger understanding of the patterns of viewer behavior, which, in turn, makes ads more impactful.

Efficiency, scalability, and privacy have been given the highest priority in the implementation, which thus ensures that the system can be widely and safely deployed at public places such as on transportation, in malls, and in smart city environments. Although the current version powerfully depends on the frontend and real-time prediction models, the system is resilient and scalable and can potentially amplify through the backend expansion, analytics dashboards, and scheduling features.

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