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Landmark-based Dataset Generation using Mediapipe

Dheeraj P[1], Ananya C[2], Afreena A[3], Raniya Rahoof E[4]
Department of Information Technology, University of Calicut

Abstract: ***This paper focuses on creating structured landmarks-based feature extraction using MediPpipe. MediaPipe is an open-source framework for building pipelines to perform computer vision inference over arbitrary sensory data such as video or audio. Hand and facial expression recognition play a significant role in various domains like Human-computer interaction, assistive technology and emotion analysis. Traditional datasets primarily rely on raw images, which pose challenges in terms of computational complexity and privacy concerns. This paper represents a alternative approach for dataset creation by extracting structured landmarks-based representation for hand gestures and facial expressions using MediaPipe***
Keywords: Mediapipe, dataset creation, landmark-based recognition, hand gesture recognition, face landmark detection

I. INTRODUCTION

Communication between Humans is not limited to verbal interaction; gestures and facial expressions play a significant role in expressing emotions and intentions. Proper identification of these non-verbal cues can significantly improve the quality of AI/ML applications such as sign language interpretation, virtual reality interactions, and mental health assessments. Such applications require a large number of high-quality datasets. Reliance on full image dataset can be computationally intensive and pose great privacy concerns. Our paper introduces a dataset generation methodology based on landmark extraction. By leveraging MediaPipe's hand and face tracking capabilities, we generate datasets containing only the necessary key points, making it ideal for training deep learning models.

II. RELATED WORK

Several datasets have been created for Hand and face gesture recognition using landmark extraction methods. However, a wide range of approaches exists for extracting and storing landmark-based data, each one with its own advantages and disadvantages. This paper specifically focuses on a structured methodology for creating a landmark-based dataset using MediaPipe framework, highlighting its efficiency, scalability and application in various tasks.

III.METHODOLOGY

A. Data Collection Approach

MediaPipe Hands and Face Mesh for extracting 3D landmark points, along with python for processing data and storing the extracted landmarks into a CSV file. The CSV file contains 3D coordinates of detected landmarks along with labels of each class.

B. Landmark Extraction

For hand gesture recognition, it captures 21 key landmark points per hand and supports detection for both hands. In the case of Facial Expression Recognition, the MediaPipe extracts 468 facial landmarks to capture various expressions.

C. Data Preprocessing

To ensure the quality of data, various preprocessing steps such as normalization, handling missing landmark points and filtering out low-confidence detections are applied. This step increases the accuracy and robustness of machine learning models trained on the dataset.

D. Data Annotation and Labelling

Each captured frame or image is assigned a class label corresponding to the gesture or facial expression being performed. The labelling process is critical for supervised learning models and involves manual verification to reduce annotation mistakes or errors.

TABLE I
LANDMARK KEY POINTS TABLE

Number of Landmarks	Details
21 per hand	Key points for fingers and palm tracking
468	Detects facial features for expression analysis

E. Implementation

Fig. 1. Illustrates a sample implementation of the technique discussed above, showcasing the process of extracting and storing landmark-based data

```python
import os
import csv
import cv2
import mediapipe as mp

# Initialize MediaPipe Hands
mp_hands = mp.solutions.hands
hands = mp_hands.Hands(static_image_mode=True, max_num_hands=2, min_detection_confidence=0.5)
mp_drawing = mp.solutions.drawing_utils

# Create/open a CSV file
csv_filename = "hand_landmarks.csv"
csv_file = open(csv_filename, 'w', newline='')
csv_writer = csv.writer(csv_file)
header = [f"hand{i+1}_x_{j}", f"hand{i+1}_y_{j}", f"hand{i+1}_z_{j}" for i in range(2) for j in range(21)]
header.append("label")
csv_writer.writerow(header)
```

Fig. 1 A sample Implementation in python

F. Data storage Format

Fig. 2. Shows a sample of the extracted landmark data stored in CSV file format. Each row represents a single frame, with columns corresponding to the 3D coordinates of the detected hand and face landmarks, together with their respective labels

	A	B	C	D	E	F	G	H	I	J	K	L
1	hand1_x_0	hand1_y_0	hand1_z_0	hand1_x_1	hand1_y_1	hand1_z_1	hand1_x_2	hand1_y_2	hand1_z_2	hand1_x_3	hand1_y_3	hand1_z_3
2	0.470415	0.43921	8.48E-08	0.497329	0.42544	0.001955	0.515265	0.404457	-0.00181	0.533319	0.393048	-0.00813
3	0.469548	0.441148	5.96E-08	0.500836	0.426486	0.001678	0.52067	0.406613	-0.00249	0.537337	0.394778	-0.00904
4	0.422108	0.659019	1.41E-07	0.44157	0.642067	0.004133	0.454093	0.61697	0.001864	0.466069	0.600941	-0.0037
5	0.423324	0.651863	1.33E-07	0.445904	0.633918	0.00404	0.457897	0.609169	0.001845	0.468423	0.593375	-0.0038
6	0.405758	0.485305	-3.97E-09	0.410449	0.454019	0.002135	0.421332	0.427247	-0.00215	0.434643	0.413126	-0.00775
7	0.420955	0.656682	1.64E-07	0.443897	0.639548	0.00479	0.457012	0.613051	0.003003	0.467549	0.596235	-0.0019
8	0.421397	0.477332	-1.51E-08	0.430102	0.45069	0.002241	0.441409	0.425927	-0.00301	0.454497	0.414141	-0.00992
9	0.248567	0.480036	2.88E-07	0.296474	0.460315	-0.00939	0.340856	0.422042	-0.01897	0.375969	0.395143	-0.03322
10	0.240215	0.552623	2.65E-07	0.300211	0.536117	-0.00646	0.353925	0.502066	-0.01899	0.396848	0.479138	-0.0376
11	0.418916	0.659445	1.63E-07	0.442564	0.641842	0.006586	0.455393	0.611977	0.00657	0.466699	0.594446	0.002891
12	0.42288	0.542527	8.27E-08	0.4214	0.50837	0.002615	0.419936	0.475761	-0.00411	0.425068	0.45185	-0.01247
13	0.422184	0.654879	1.18E-07	0.443745	0.636471	0.004571	0.455627	0.612175	0.002111	0.466827	0.597921	-0.00385
14	0.424602	0.527876	9.89E-08	0.446519	0.503525	-0.0018	0.457737	0.477806	-0.00931	0.469307	0.462199	-0.01837
15	0.461647	0.429157	6.85E-08	0.496079	0.413452	0.003108	0.518399	0.389457	-0.00122	0.53805	0.376302	-0.00858
16	0.587995	0.481504	-2.51E-07	0.575455	0.457357	-0.00137	0.556372	0.440167	-0.01033	0.535849	0.437068	-0.01957
17	0.233412	0.503417	2.76E-07	0.286039	0.470071	-0.00693	0.328142	0.427806	-0.01723	0.363397	0.398309	-0.03366
18	0.424204	0.635494	1.36E-07	0.442133	0.62127	0.00257	0.454821	0.60003	-0.00032	0.466695	0.588299	-0.0059
19	0.458097	0.456851	7.09E-08	0.483767	0.431527	0.003082	0.496912	0.403314	0.00057	0.510184	0.385574	-0.00465
20	0.421139	0.656782	1.36E-07	0.441791	0.638587	0.003529	0.453496	0.614061	0.000721	0.46566	0.598792	-0.00534
21	0.406815	0.485645	6.35E-09	0.413088	0.454965	0.00204	0.426639	0.428786	-0.00296	0.44146	0.417577	-0.00913
22	0.51678	0.427708	-2.45E-07	0.489669	0.423927	0.001209	0.46619	0.408483	-0.00396	0.448437	0.405119	-0.011
23	0.421139	0.656782	1.36E-07	0.441791	0.638587	0.003529	0.453496	0.614061	0.000721	0.46566	0.598792	-0.00534
24	0.4736	0.724984	7.69E-08	0.490303	0.686872	0.004861	0.494575	0.647563	0.003123	0.502723	0.620882	-0.00276
25	0.463254	0.448429	1.23E-07	0.492504	0.428805	0.002221	0.509208	0.404192	-0.00209	0.524898	0.388748	-0.00896
26	0.419357	0.657488	1.05E-07	0.440799	0.639971	0.004869	0.453283	0.615197	0.002978	0.465499	0.600034	-0.00251
27	0.52956	0.432782	-2.99E-07	0.500426	0.416267	0.001345	0.479457	0.391961	-0.00324	0.460698	0.381431	-0.01014

	M	N	O	P	Q	R	S	T	U	V	W
1	hand1_x_4	hand1_y_4	hand1_z_4	hand1_x_5	hand1_y_5	hand1_z_5	hand1_x_6	hand1_y_6	hand1_z_6	hand1_x_7	hand1_y_7
2	0.545234	0.381172	-0.01317	0.481389	0.340125	0.001322	0.512454	0.328483	-0.00991	0.530726	0.344588
3	0.547259	0.381339	-0.01434	0.486221	0.338945	0.000448	0.518461	0.327857	-0.01082	0.536183	0.344487
4	0.471097	0.582826	-0.00837	0.417929	0.569418	0.004917	0.42995	0.536027	-0.00508	0.451427	0.542523
5	0.472336	0.576062	-0.00889	0.420704	0.571532	0.003296	0.432169	0.536006	-0.00911	0.452381	0.541232
6	0.446059	0.407808	-0.01318	0.416807	0.40882	-0.0102	0.440358	0.396167	-0.01988	0.452699	0.408307
7	0.468276	0.577669	-0.00597	0.417821	0.570903	0.002772	0.431814	0.537995	-0.0073	0.452787	0.544546
8	0.464769	0.407107	-0.01651	0.433272	0.404096	-0.01208	0.453207	0.384391	-0.02365	0.467457	0.400659
9	0.362125	0.370901	-0.04681	0.270445	0.365551	-0.00039	0.299085	0.321512	-0.03536	0.340351	0.335271
10	0.401257	0.44686	-0.05554	0.297477	0.432404	-0.00119	0.324806	0.375648	-0.03609	0.36996	0.395278
11	0.470946	0.575218	-0.00039	0.41722	0.571703	0.008745	0.430376	0.536459	-0.00072	0.451282	0.538103
12	0.431604	0.434401	-0.0206	0.396015	0.469609	-0.01861	0.416226	0.429136	-0.03401	0.439647	0.431135
13	0.469184	0.581873	-0.00928	0.418741	0.56823	0.002818	0.431765	0.533999	-0.00978	0.452568	0.541404
14	0.473624	0.450401	-0.02652	0.40881	0.439448	-0.01536	0.432111	0.405939	-0.03115	0.454489	0.417878
15	0.550553	0.364586	-0.01462	0.47886	0.311899	0.000949	0.516443	0.297033	-0.01232	0.538375	0.317059
16	0.523051	0.44517	-0.02934	0.578912	0.403681	-0.02484	0.542516	0.394867	-0.03747	0.527303	0.414675
17	0.350381	0.37502	-0.04896	0.250791	0.365326	0.007375	0.266209	0.316833	-0.02736	0.308424	0.328392
18	0.471336	0.573375	-0.01077	0.422538	0.554285	0.00201	0.437153	0.526146	-0.00781	0.455619	0.53265
19	0.517279	0.371709	-0.00863	0.448906	0.353112	0.004048	0.477842	0.331812	-0.0064	0.499048	0.339249
20	0.470657	0.580879	-0.01074	0.417755	0.57082	0.002741	0.431529	0.535424	-0.00932	0.451614	0.542497
21	0.451701	0.415141	-0.01516	0.419398	0.406311	-0.01201	0.442838	0.396362	-0.0218	0.455442	0.407438
22	0.433498	0.400856	-0.01828	0.488136	0.336033	-0.0059	0.454458	0.334183	-0.01741	0.438372	0.356434
23	0.470657	0.580879	-0.01074	0.417755	0.57082	0.002741	0.431529	0.535424	-0.00932	0.451614	0.542497
24	0.50376	0.596305	-0.00764	0.434625	0.626613	0.006835	0.43994	0.578524	-0.00757	0.466443	0.575162
25	0.534985	0.375478	-0.01472	0.466341	0.345318	-0.00101	0.497328	0.32636	-0.01345	0.519248	0.339422
26	0.467271	0.584448	-0.00729	0.415657	0.569182	0.006585	0.431609	0.536361	-0.00529	0.452396	0.545242
27	0.445626	0.369564	-0.01671	0.51871	0.322068	-0.00018	0.484761	0.308867	-0.01111	0.46336	0.324725

Fig. 2 Sample Landmark Data Stored in CSV Format

IV. APPLICATIONS OF LANDMARK-BASED DATASETS

Landmarks-based datasets have a wide range of applications, across various domains. They are extremely efficient for training models for sign language interpretation and touchless control systems. In facial expression analysis, they aid in emotion detection for healthcare and entertainment applications. Additionally, these datasets enhance privacy-protection by reducing reliance on raw images while maintaining recognition accuracy. Furthermore, they contribute to multimodal fusion techniques that combine facial and hand gestures for improved human-computer interaction models.

V. CONCLUSION

This paper introduces a structured, landmark-based dataset for hand gesture and facial expression recognition, giving a computationally efficient and privacy-focused alternative to traditional image-based datasets. By making use of the MediaPipe framework for three-dimensional landmark extraction, we enable the development of robust AI models for a wide range of applications like sign language detection, human-computer interaction and emotion detection. Future work includes expanding dataset diversity, incorporating motion dynamics, and benchmarking deep learning models on the dataset.

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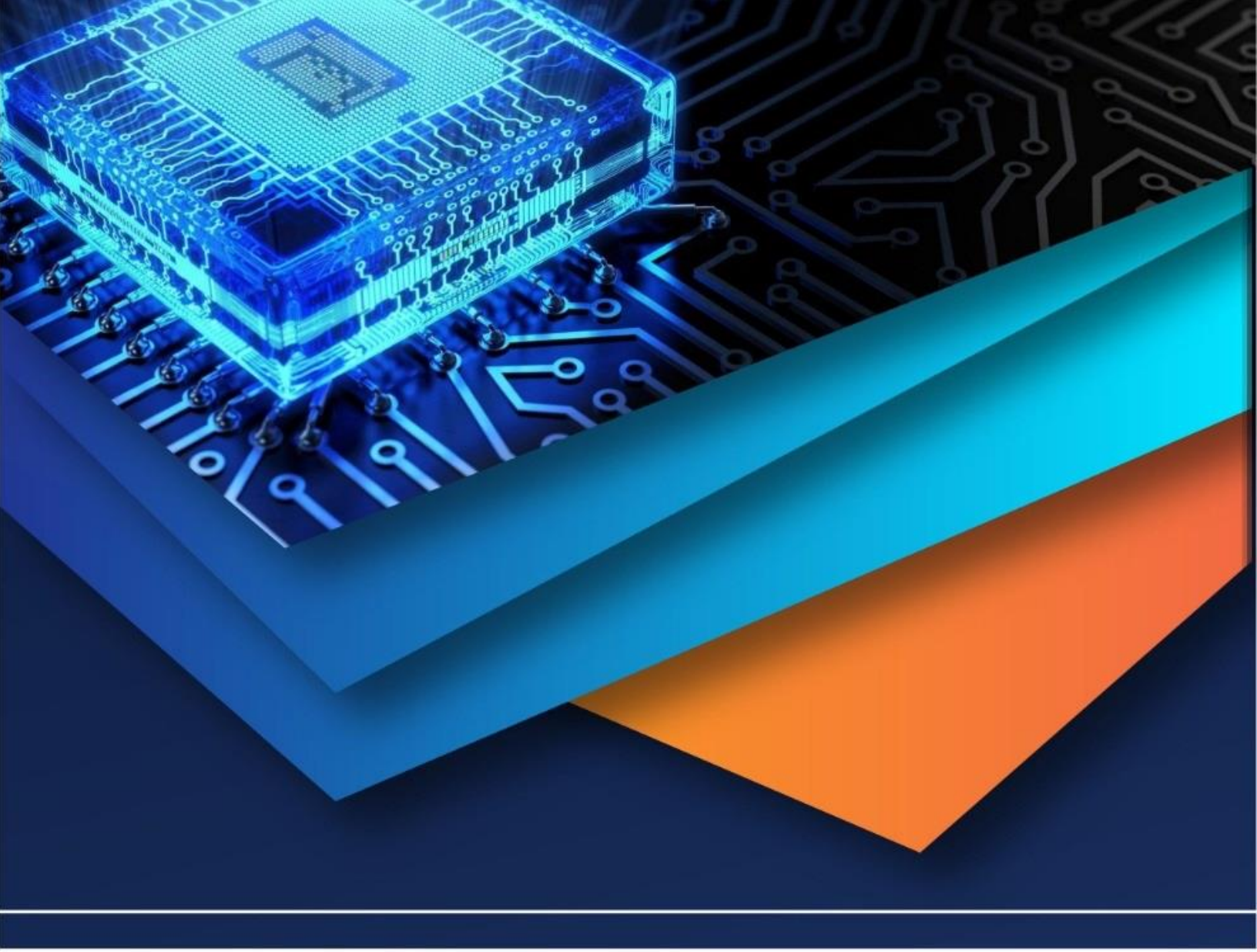

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