GAIT ASSESSMENT FRAMEWORK FOR DEPRESSION DETECTION

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Introduction:

Depression is an escalating global issue that impacts millions and often remains unnoticed due to societal stigma, lack of knowledge, or shortcomings in current diagnostic techniques. Timely identification and intervention are crucial for managing this mental health disorder, yet conventional methods primarily rely on subjective evaluations and self-reported feelings. To fill this void, our project introduces a non-invasive, data-centric solution: A Gait Assessment Framework for Depression Detection.

This initiative harnesses the interplay between biomechanics and artificial intelligence to evaluate an individual's gait and facial expressions—two subtle but significant indicators of emotional and psychological well-being. By utilizing Microsoft Kinect sensors, we capture 3D joint coordinates and facial video while individuals are walking, which allows us to extract both spatiotemporal gait characteristics and micro-expressions. These data elements are then processed and utilized in machine learning models designed to accurately classify levels of depression.

The significance of this approach lies in its ability for real-time evaluation, cost-effectiveness, and wide accessibility. Unlike traditional clinical assessments that necessitate trained professionals and extended consultation periods, our system can be implemented in everyday settings such as schools, workplaces, or clinics for quick screenings. It is well-suited to meet the rising demand for remote and telehealth services, providing a scalable method for monitoring mental health.

In a broader perspective, this project connects healthcare with technology, giving communities a proactive tool for mental wellness. Its innovative application of AI and sensor technology positions it at the crossroads of engineering and social impact, making it highly pertinent in today's health-conscious and digitally integrated society.

Objectives:

1. Detect signs of depression in individuals in real-time.
2. Analyze both gait patterns and facial features for behavioral cues.
3. Utilize Kinect motion capture technology for 3D joint and facial data collection.
4. Apply machine learning techniques to classify depression levels.
5. Identify specific physical and emotional indicators associated with depression.
6. Provide a non-invasive mental health monitoring system.

Methodology:

1. Data Gathering: Utilize Kinect sensors to obtain 3D joint coordinates of individuals while they are walking. At the same time, gather facial video data to evaluate facial expressions and movements.

2. Data Preparation: Normalize and filter the gathered 3D joint coordinates to eliminate noise.Ensure synchronization of facial and gait data for temporal alignment.Segment walking cycles and identify key frames from the gait motion for analysis.

3. Feature Extraction:

- Gait Analysis Features:

a. Spatiotemporal Features: Assess parameters like body swaying, arm swings, vertical head movement, head posture, stride length, toe clearance, and walking speed.

b. Time-Domain Features: Extract statistical characteristics (mean, standard deviation, skewness, kurtosis) from the 3D coordinates of 20 joints.

c. Frequency-Domain Features: Apply Discrete Fourier Transform (DFT) to examine periodicity and derive frequency-domain characteristics of joint motions.

- Facial Features: Employ machine learning to correlate facial expression patterns with emotional states.

4. Feature Integration: Merge gait features with facial features to form a holistic representation of the individual's physical and emotional condition.

5. Machine Learning: Train supervised machine learning algorithms (e.g., Random Forest, SVM, or Neural Networks) using labeled datasets to categorize depression levels.

6. Classifying: Use the trained model to classify individuals into groups (e.g., depressed, mildly depressed, and non-depressed) based on the extracted features.

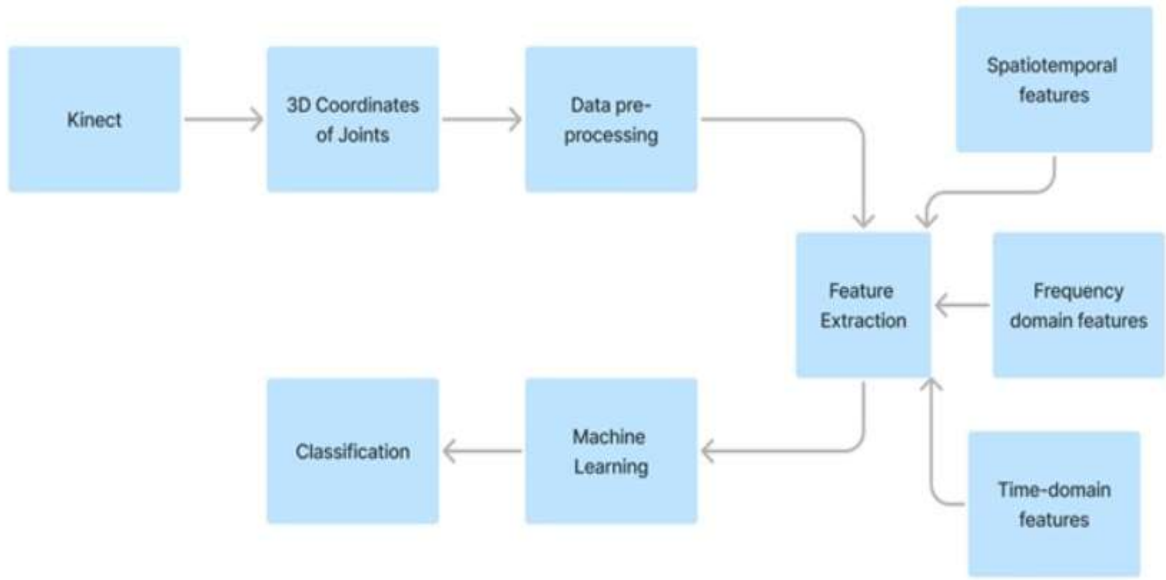

Figure 1: Methodology

Result and Conclusion:

At the present phase of our project utilizing Kinect for depression detection, we have successfully gathered several gait parameters from 3D skeleton data, which include body swaying, arm movement, stride length, toe clearance, walking speed, head position, and vertical head movement [Table 1 & Table 2]. These parameters were determined using Kinect's skeletal tracking, smoothed with a Gaussian filter, and transformed into a hip-relative coordinate system for uniformity.

Table 1: Derived parameters

Velocity (m/s)	Left Swing ArcLength (m)	Right Swing ArcLength (m)	Stride Length (m)	swayChange (m)	Right Elbow Angle (deg)
0	0	0	NaN	0	0
0	0	0	NaN	0	0
0	0	0	NaN	0	0
4.13	0	0.1	0.06	-0.04	150
1.67	0.02	0.12	0.05	0.03	157
1.55	0.14	0.05	0.07	0.02	100
1.8	0.03	0.15	0.07	0.01	148
0.8	0.1	0.13	0.05	0	163
0.81	0.09	0	0.03	-0.01	155
0.77	0.06	0.02	0.05	-0.01	143
1.75	0.11	0.05	0.05	0.01	170
0.84	0.12	0.03	0.05	-0.02	137
0.89	0.14	0.03	0.07	0.01	165
0.64	0.19	0.03	0.04	-0.01	172

Table 2: Derived parameters

Left Elbow Angle (deg)	Right Knee Angle (deg)	Left Knee Angle (deg)	Head Posture Angle (deg)	Vertical Head Movement (m)
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
175	134	105	71.82	0.19
173	176	158	71.41	0.21
75	130	154	80.3	0.2
175	169	177	118.59	0.14
165	179	150	118.56	0.16
142	172	168	78.6	0.15
163	162	163	59.89	0.17
158	169	168	61.24	0.17
154	164	164	48.22	0.13
152	134	114	117.76	0.14

Gathering authentic data from patients diagnosed with depression can be difficult, as these individuals frequently hesitate to take part in studies; however, the parameters validated by psychologists can still provide compelling proof of the concept.

The identified features were organized into a dataset appropriate for machine learning classification. We have tried out several basic classifiers, and initial outcomes suggest a promising capacity for recognizing depression risk based solely on gait dynamics.

We are currently only halfway through the complete implementation. The next significant step involves incorporating features based on facial expressions.This will enable us to utilize facial characteristics with our existing gait parameters.

Project Outcome & Industry Relevance:

This project seeks to revolutionize mental health services by facilitating prompt, non-invasive, and easily accessible detection of depression via real-time analysis of gait and facial expressions. It promotes early intervention, minimizes the necessity for extensive evaluations, and provides affordable, data-driven insights for tailored treatment.

Working Model vs. Simulation/Study:

This project created a model that is partially operational, utilizing the Microsoft Kinect for the acquisition and analysis of real-time 3D gait data. Important characteristics such as body swaying, stride length, and arm movement were identified and displayed through a C# application featuring a XAML interface. The aspect related to facial expressions, drawing inspiration from referenced studies, remains in the planning phase.

Project Outcomes and Learnings:

1. Classification of Depression Levels: The system categorizes individuals into various levels of depression, such as not depressed, mildly depressed, or severely depressed, using their gait and facial characteristics.

2. Non-Intrusive Mental Health Monitoring: A budget-friendly and user-friendly system for ongoing mental health evaluations without the need for invasive methods.

Future Scope:

1. Validating the data obtained from this work with real subjects is a critical issue. Due to the unavailability of readily willing volunteers diagnosed with depression, this study can currently be considered only as a proof of concept. Future work

should focus on collaborating with clinical institutions to collect data from actual patients for more accurate validation.

2. Development of a real-time monitoring system that continuously tracks depression indicators during natural walking or daily interactions.
3. Support for portable or mobile sensors (like Azure Kinect or smartphone-based depth cameras) to increase accessibility and usability.
4. Exploration of emotionally-triggered gait variations, analyzing how mood influences physical movement in real time.
5. Extension to detect other mental health conditions such as anxiety or bipolar disorder by training on relevant behavioral cues.
6. Addition of feedback or alert systems that notify users or healthcare providers about possible depression symptoms.
7. Study of gender and age-related differences in depression-linked movement and expression patterns.