Leveraging AI to Mitigate Risks in Yoga Practice: A Real-Time Posture Correction Application

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Abstract: The extensive propagation of yoga, once reserved for isolated spiritual communities, has brought several advantages as more and more people have gained access to a holistic well-being system. Nonetheless, while many individuals have benefited from the influence of yoga, lax application of its various regimens has resulted in a hike in yoga-related injuries. The following paper explores current AI tools for yoga and then elucidates the physical, psychological, and long-term adverse effects of improper yoga practice, with supporting data and statistics. Furthermore, it suggests an AI-equipped application that alters the potential of injuries arising from incorrect body movements during yoga. Next, particular technical features of the app are enumerated, demonstrating how machine learning aids in data analytics to prevent misapplication and take care of user privacy issues. Finally, the challenges of the proposed solution's adoption, usability, and ethical usage are addressed, and suggestions are offered to circumvent such hurdles.

1 INTRODUCTION

Yoga originated in India over 2,000 years ago, and it is now a primary global industry and a kaleidoscopic cultural phenomenon enjoyed by hundreds of millions worldwide. In 2020, the Yoga Alliance, the US's most prominent non-profit association representing the yoga community, found that almost 36 million people in the US practice yoga. Annual growth since 2016 has been close to 10 percent. However, as global yoga continues to expand, the number of yoga injuries is also rising. One study found that the total number of injuries treated at emergency departments in the US between 2014 and 2017, with a primary diagnosis related to a yoga practice, increased by 45 percent. Three of the most common yoga-related injuries are sprains, strains, and fractures.

The physiological, mental, and chronic harmful consequences of incorrect yoga practice are discussed in detail. Then, an AI-based yoga application is proposed will be provided real time alerts to correct posture utilising data analytics and machine learning.

2 YOGA AND AI

Yoga and AI are increasingly merging, combining yoga's mindfulness and physical discipline with the technological advancements of artificial intelligence. This convergence allows practitioners to enhance their routines, personalize experiences, and make yoga more accessible.

2.1 AI-Powered Yoga Apps

With apps that provide real-time feedback during a home-based, step-by-step yoga practice routine, AI is impacting how yoga is performed as a discipline. Some popular AI-powered apps include Skill Yoga Movement Coach, which uses AI and computer vision to track the practitioner's body alignment in real-time. It provides feedback on yoga poses, helping practitioners improve posture and form without needing a physical instructor. Alo Moves Powered by AI, the app recommends yoga classes based on progress, fitness goals, and other user preferences. QuickPose provides Real-time feedback on pose accuracy and promotes user confidence and safety while practicing. QuickPose is an AI-powered pose

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detection software that gives users real-time feedback on pose accuracy and helps improve a user's pose. However, these existing tool are subscription based and would put it out of reach of a huge population segment.

2.2 AI in Wearable Technology

AI has also penetrated wearable technology, offering an additional analytical layer for yoga practice. Fitness trackers and other body-worn technology can read the practitioner's physiological data (heart rate, breathing patterns) and, by using AI, suggest tweaks or the best times to practice. For instance, exercise trackers such as Fitbit and Apple Watch, which make use of sensors like accelerometers, gyroscopes, heart rate monitors, and photo-optic sensors, among others, include AI-powered yoga tracking features to help assess poses in real-time, provide users with periodic feedback on their progress over time, and provide personalized coaching recommendations. The efficacy of these apps would depend on ethical and responsible data usage in line with the existing data governing principles.

2.3 Virtual Yoga Instructors

AI is used to create virtual instructors that guide users through yoga sessions, offering convenience and real-time personalization. Yoga is no longer limited to set time slots since users can connect with virtual yoga instructors and spontaneously begin their practice at any time of the day or night. Incorporating the flexibility of technology, the AI-powered app Yogaia allows one to connect with a live virtual class that adapts to your improvement.

2.4 Mental Health and Meditation Support

AI enhances mental wellness in yoga by offering personalized meditation and mindfulness practices. Apps such as Calm and Headspace give users tailored meditation and mindfulness sessions using AI that learns a user's mood and responds and adjusts a session based on biometric signals and a user's rating of their stress levels. These apps use AI to provide a meditation or breathing exercise based on data and user inputs, making the mental benefits of yoga more attainable.

2.5 AI in Yoga Studios

AI is being used not only to support individual practice but also to enhance the in-studio experience. For example, with AI, a studio may be able to shape class settings—such as the lighting or temperature—based on the preferences of whoever is walking through the door. Alternatively, AI can help teachers better support learners by identifying their needs based on past injuries or class goals.

2.6 Yoga Therapy and Rehabilitation

Tools are being developed for yoga therapy and rehabilitation that assist people in recovering from injuries, tracking their recovery, and offer suggested yoga poses to promote rehabilitation while informing the practitioners of what to avoid to avoid further injury.

However, AI cannot replace the human connection with other practitioners and teachers that yoga brings. AI tools cannot replace the more in-depth and spiritual experiences that have attracted people to yoga. Like in other domains, many practitioners and experts have jumped onto the bandwagon of the innovations in AI tools as methods to assist bigger audiences in traditional yoga teaching rather than replacing it. In conclusion, the great benefits that AI is bringing to yoga are opening up new horizons in terms of accessibility, personalization, and ease of practice.

3 THE PHYSICAL AND MENTAL RISKS OF IMPROPER YOGA PRACTICE

3.1 Physical Injuries: Data and Statistics

While yoga has established its place in the world of exercise for its potential to improve flexibility, muscle tone, and mental well-being, injury from poor practice is sadly a regular occurrence. Research published in the Journal of Bodywork and Movement Therapies in 2018 reveals that, of the yoga students they surveyed, 20 percent had, at some time, suffered at least one injury severe enough to disrupt their regular practice. Here are the common injuries:

3.1.1 Muscle Strains and Sprains

Overextension in forward bends, Hamstring injuries, and splits are some joint muscle strains and sprains caused by improper yoga practice. For example, a study published in the American Journal of Science

and Medicine in Sports concluded that 33 percent of injuries sustained in yoga were hamstring strains.

3.1.2 In Joints

Weight-bearing poses such as downward dog and handstands put your wrists, shoulders, and knees at risk of injury. A 2017 study found that 21 percent of yoga injuries affect the upper extremities more than any other body part, primarily due to compression and faulty alignment.

3.1.3 Spine Problems

Spinal and back injuries such as herniated discs and sciatica can result from the incorrect execution of spinal twists or back-bending poses. A study in the International Journal of Yoga found that 10 percent of practitioners reported chronic lower back pain from yoga practice, pointing to improper technique.

3.1.4 Balance-Related Injuries

Balance poses (like tree poses or headstands) commonly have poor alignment and often cause a fall. The British Journal of Sports Medicine suggests that balance-related injuries account for 14 percent of all yoga injuries and are often associated with fractures or concussions.

3.2 Mental and Emotional Strain

When practiced appropriately, yoga can make the practitioner mentally and physically light and supple, but it can have numerous undesirable emotional and mental impacts if practiced wrongly.

3.2.1 Stress and Anxiety

When poses are held and advanced poses are performed, both of which can involve exerting physical strength and **s**train, stress and its companions, anxiety – mainly focussed upon performance – can result. A 2019 paper in Brain plasticityreported that 15 percent of them found that the performance pressures led to a rise in their feelings of anxiety.

3.2.2 Mental Suffering

Misalignment and discomfort could cause a type of mental fatigue, reducing the intended meditative benefits. A study in the Evidence-based Complementary and Alternative Medicine showed that 25 percent of practitioners reported having lower Mindfulness, becoming less focused, and getting less relaxation purported to come from meditation practice, attributable to poor alignment due to inadequate instruction.

3.3 Long-Term Bodily Harm

Not only can the aftershock of a poorly practiced or arbitrary pose result in acute injury, but it can also take years to manifest as a chronic disease.

3.3.1 Misalignment

Pelvic misalignment, in particular, can lead to pain in the lower back and neck. An article in The Journal of Yoga and Physical Therapy reported that one-third of yoga practitioners who had been practicing for an extended period developed chronic pain as a result of misalignment.

3.3.2 Postural Imbalances

Chronic incorrect practice may also cause postural issues, such as the development of muscular imbalances. One study from 202 found that 22 percent of practitioners developed such musculoskeletal imbalances from chronic incorrect postures.

3.3.3 Neurological Damage

Poses involving neck or head misalignment could cause neurological damage. Rare, severe injuries to the neck area, to specific nerves, and even stroke have been reported. For instance, The Public Library of Science published cases of nerve compression due to inappropriate headstands.

3.4 The Role of Technology in Preventing Improper Yoga Practice

As improper yoga practice is becoming common, we need technological solutions that can help reduce injury by providing real-time feedback on the asanas and giving immediate corrective feedback. This paper proposes an Artificial Intelligence (AI) based yoga app that can track a person's posture and give feedback when required. The difficulty in practicing various asanas increases due to the excessive burden of professional work, unhealthy lifestyles, and eating habits, causing many youngsters to develop weak physical conditions. These factors are leading to cases of improper yoga and unintended injuries. Yoga is a beneficial practice in daily life, resulting in holistic wellness. We propose an AI-based mobile yoga app to address the abovementioned problems. The app can

alert and predict people's movements while performing various asanas. The algorithm implemented in the app enables it to predict the outcome of practice and give immediate feedback when needed. During the practice, the app's AI will constantly keep track of the posture. While it will allow users to proceed when the expected posture is achieved, it will intervene if the user's body posture is incorrect. The proposed app not only alters the incorrect yoga poses but also provides virtual assistance if needed, as well as initiating emergency protocol if a severe potential injury persists. Hence, this will reduce the issues and injuries from improper yoga practice.

4 KEY FEATURES OF THE AI-POWERED YOGA APPLICATION

4.1 Real-Time Pose Estimation

Behind this, computer vision and pose estimation algorithms are used to track with the the proposed solution enhances mobile device's camera and compare it with ones from a database. At the heart of the app is its pose estimation system, which relies on computer vision algorithms such as OpenPose or MoveNet to detect and track landmarks (such as shoulders, hips, knees, and ankles) on the human body in real time.

The app relies upon a convolutional neural network (CNN) trained on a sizeable open-source dataset of varied yoga poses. This allows it to accurately identify many of humans' essential body landmarks, such as joints, angles, and muscle gears.

4.2 Personalized Feedback and Correction

After the practitioner assumes a pose, the app immediately explains which areas they must correct until their body is aligned correctly. For instance, if the practitioner is practicing the cobra pose and their spine is not straight, the app will alert them and guide them to straighten it better.

The app uses data analytics processing and extraction to interpret user data and transform the raw posture at a specific time into user-actionable insights. With machine learning models specially built for supervised learning, the posture self-assessment app detects patterns in the wrong posture and predicts posture risks.

It tailors its feedback to the practitioner's unique body and the specific history of practice found in its database.

4.3 Data-Driven Insights and Progress Tracking

Once installed, the application takes a lifetime inventory of the user's posture as they practice, crowdsourcing the data and analyzing it for repetitive tendencies and errant postural quirks over the long term. The data is combined with knowledge about the standard movements that lead to repetitive strain and cramping to generate personalized practice plans and workout routines tailored to the user's particular areas of weakness. The app uses reinforcement learning techniques, in part, to calibrate the feedback and practice routines. The more it learns about the user, the better the app becomes at helping the user improve.

A dashboard will allow individuals to track their progress via visual reports, such as improvements in skeletal alignment, range of motion, and other assessments of body posture quality.

4.4 AI-Driven Personalization

The app continuously becomes more adept at making posture corrections using machine learning. The app learns about the user's practice style – the more the user works with the app, the more refined the AI can become in making corrections and improving overall performance.

Additionally, users get their yoga instruction tailored to their objectives by selecting their target (flexibility, strength, balance, and so on), with each workout catered accordingly.

5 TECHNICAL FLOW

5.1 Overall Flow

5.1.1 Input Video Data

This is the stage that will handle the video data, which processes the video feed from the user's mobile camera. The characteristics of the input such as encoding format (e.g., MP4, AVI), resolution (e.g.,1080p, 4K), and frame rate (e.g., 30fps, 60fps), are analysed and normalised if needed.

5.1.2 Extract Metadata

In the next step, the metadata is extracted, such as the file name, video and audio duration, video and audio

codecs (e.g., H.264, AAC), aspect ratio, frame rate, and bit rate, among other features. This metadata is important because it informs various aspects of the preprocessing and AI modeling so that the video is transformed in ways appropriate to its specific form.

5.1.3 Preprocessing Stage

The preprocessing step, as the first stage of the data pipeline, is fundamental for the AI model's input as it consists of a few sub-processes:

- Frame Extraction: Each frame in the video is separated from the others.
- Resolution Adjustment: The decomposed video stream comprises extracted frames that are then rescaled to the target resolution and aspect ratio. As a result, the output complies with both its visual quality and the resolution requirements set by its use application.
- Noise Reduction: This subprocess involves applying noise filters to the frames to eliminate unwanted noises visually, improving the quality of the video.
- Colour Correction: Brightness, contrast, saturation, and hue, among other frame characteristics, are adjusted so that shots are consistent.

5.1.4 AI Model Input Data Preparation

After preprocessing, the video data is prepared for AI model input through several techniques:

- Feature Extraction: Extracting salient features like edge, corner, texture, interest points, and motion vectors from the video frames. All these features form the essential ingredients of the AI model to understand what the video contains.
- Object Detection: The algorithm recognizes objects within the video and assigns them to a set of pre-defined classes to help extract meaning from the video.
- Scene Segmentation: The video is divided into multiple regions and scenes, which can help the AI model improve its predictions on each segment because each region represents a different activity of the yoga practitioner.

5.1.5 AI Model Processing

At this point, the (preprocessed) video stream data are fed into the AI model, which is used to train model weights, neural network architecture parameters, and inference parameters to perform AI-driven enhancements and analyses such as object recognition, action detection, and scene understanding.

5.1.6 Post-Processing Stage

Following the AI model's processing, the video undergoes post-processing:

- Overlay Annotations: The video is shown with detected objects, labels, and tracking data. This step transforms the event video by adding annotations from the AI models, allowing the views to customise the view.
- Rendering the final frames: This is the final step where everything gets knitted together for the user display.

5.1.7 Output Generation

The last stage involves generating the final outputs:

- Deliver final Video: The processed video is displayed in real-time.
- Logs/reports: The system logs and reports processing steps, errors, and performance metrics in detail. This is critical for understanding performance, debugging errors, and maintaining the system.

5.2 User Alert System

5.2.1 Capture Video Data

When the session starts, the mobile starts to capture the user practising yoga. This captured data enables constant estimation of the posture during the entire session.

5.2.2 Analyze Posture

This is where the AI takes the incoming live video feed and runs it through computer vision and algorithms to determine critical points on the user's body—for instance, the shoulders, the hips, the ankles, etc. Once the various parts of the user's body are successfully identified, the AI system compares the user's 'live' posture with pre-trained ideal postures in the AI's database. The basis of these ideal postures is standard yogic positions from open-sourced data carefully calibrated by human experts such as yoga teachers.

5.2.3 Posture Assessment

In the first stage, the AI analyses the posture. If the posture is correct, the system monitors it continuously

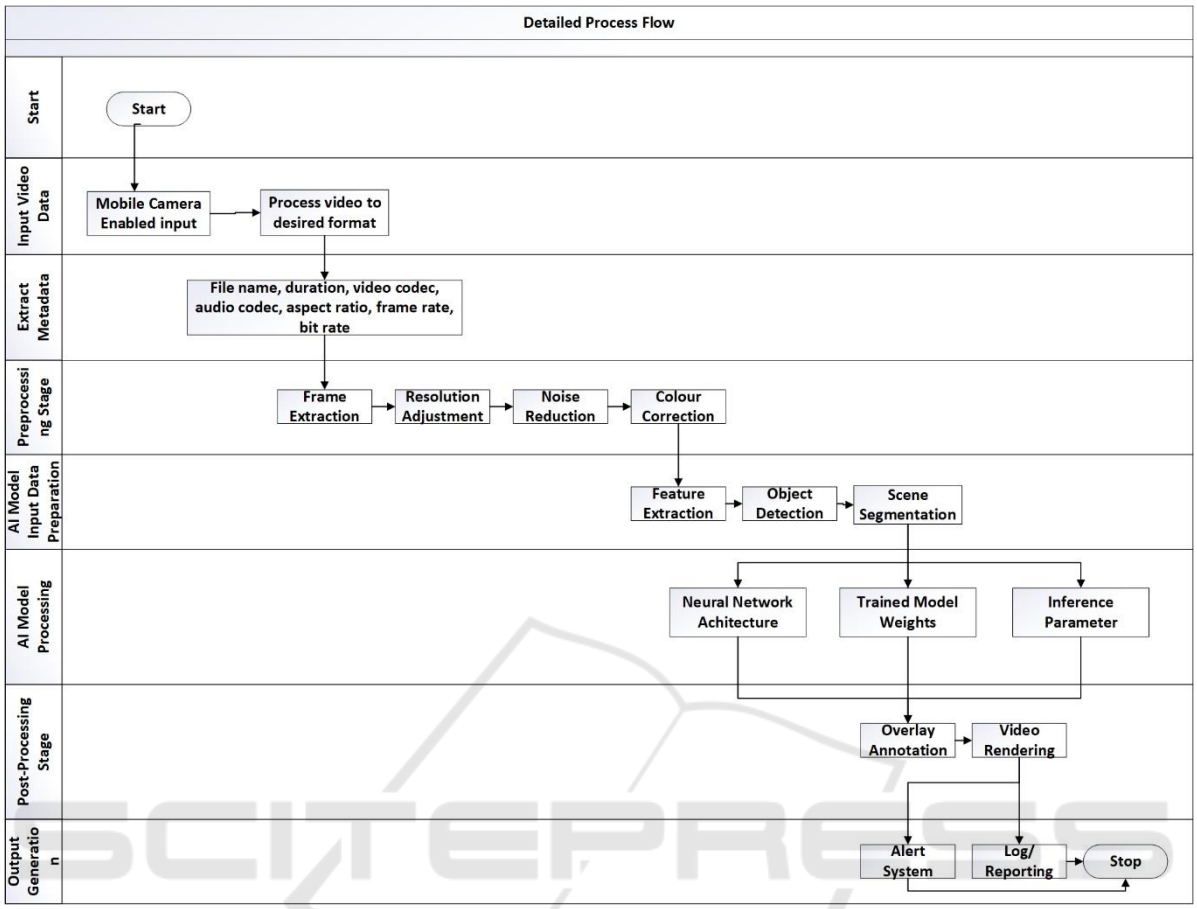

Figure 1: Overall technical flow.

without taking any action. However, if the AI understands that the posture is incorrect, the AI will alert the user, and the user is expected to correct their posture. The alert is sent via visual. However, the auditory alert settings will be dependent on the user's needs and preferences.

5.2.4 Reassessment

After the alert, the system checks whether the posture has been corrected. If the user has corrected the posture, the system turns back to the normal monitoring state. In contrast, if the posture is still not corrected, the risk level counter, which counts the number of times that the user has not corrected his/her posture, is incremented. This counter is used for risk assessment over a prolonged period of bad posture during the session.

5.2.5 Risk Level Check

There is an active monitoring of the user's posture with the consequent counter of the risk level. If the risk level is not high, the system continues monitoring with periodic alerts. If the risk level exceeds a limit, the system suggests that the user take a break to prevent damage due to prolonged maintenance of the incorrect posture.

5.2.6 Continuous Risk Check

After a break, the system checks whether the user resumes an unsafe posture. If the user maintains the correct position, the system continues the monitoring. However, if the user reverts to continuing with the unsafe posture, the risk counter increases again, which makes it more probable that the level of intervention escalates.

5.2.7 Severe Risk Assessment

If the risk counter rises beyond the threshold, the system takes more elevated measures by connecting the user to a virtual yoga instructor. Ideally, the instructor should offer tailored recommendations to help the user improve posture and perform the

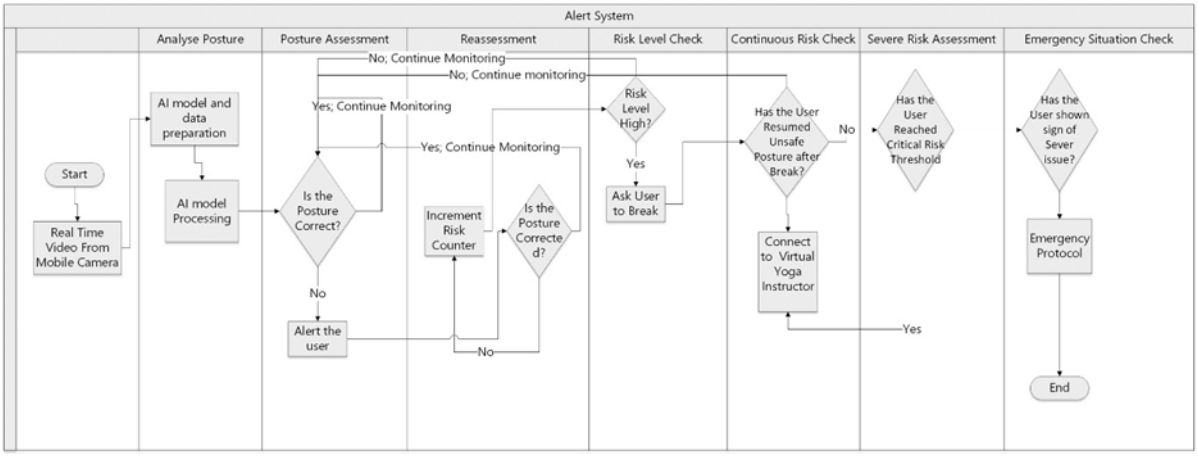

Figure 2: Alert system technical flow.

physical activity/exercise safely and more accurately. Normally, it is difficult for a person receiving a program guided by textual or video instructions to adjust their behavior because they cannot quickly or accurately receive feedback. The virtual instructor can promptly respond to the user's activity and outcomes to facilitate behavior change.

5.2.8 Emergency Situation Check

If extreme issues are detected, such as those that could harm the user, the system deploys an emergency dial sequence. This action could be a call to 911 or some other predetermined emergency procedure.

5.2.9 End

The session ends only when the user stops or is halted due to a high-risk signal by the system at the end of the exercise routine. The app saves the collected data for future analysis and helps users compare and optimize their posture over time.

6 CHALLENGES

6.1 Adoption and Reach

Even though the majority of people around the world now have access to a smartphone, reliable access to suitable hardware and stable internet is limited in some areas. For instance, Indian women are 15 percent less likely to own a mobile phone and 33 percent less likely to use mobile internet services than men. Furthermore, only 31 percent of the rural population uses the Internet compared to 67 percent of their urban counterparts. The variance in culture, language, and dialects must all be factored in, which would substantially add to execution cost and time.

6.2 Technical Limitations

Real-time video processing apps could face several limitations due to computational complexity, data throughput, and system resource constraints. High computational demands for tasks such as object detection, motion tracking, or image enhancement can strain mobile device processors, often leading to performance lags and overheating issues. Predominantly, apps rely on low-latency data processing, but maintaining frame rate and resolution in real-time scenarios can be challenging, especially with limited processing power and memory on mobile devices.

Bandwidth limitations also pose a significant challenge. Real-time video applications require substantial data throughput, particularly for high-definition streams, which can cause delays or reduced video quality when network conditions are suboptimal. Additionally, battery consumption is another concern, as continuous real-time processing rapidly depletes power in mobile environments.

6.3 User Experience and Engagement

To help users stay consistent with their practice, the app employs tactics like gamification (earning badges, etc.) and awarding rewards for things such as consistently completing practice sessions every few days for a specified number of times.

The app also has built-in social functions that enable users to share their journey with friends or join community challenges, which help create a sense of community and motivate the user.

6.4 Ethical Considerations and Data Privacy

The collection and administration of biometric data raise ethical issues around consent and privacy. The app should address these through full disclosure and user control over data, following the GDPR.

The data is pseudonymized and encrypted; only authorized personnel can access it. It should be entirely under user control and disabled or deleted whenever the user wants.

7 CONCLUSION

As yoga becomes more and more pervasive, not just as a practice of wellness but also as a competitive sport, the risks associated with the performance of improper yoga increase as well. Our proposed AI yoga application is a technological solution to these risks, offering accurate analysis of the data of different users for ideal yoga practice. The application relies on the latest AI and machine learning applications, such as deep learning, production, and pattern recognition algorithms. Using the latest innovations in deep learning, we have proposed an innovative solution to help users avoid injuries and make their practice safer and more effective. Hence, the proposed solution likely enhances the benefits of AI systems for society and ensures continued cultural respect for yoga. For such technology to be accessible and usable globally, challenges ranging from access, usability, and user-interface issues to data privacy and cultural sensitivity must be holistically addressed for the effective implementation and usage of the proposed app.

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