Chapter 1

Chapter 6: Conclusions and Evaluation

This chapter presents a critical assessment of the developed Multi-Sensor Recording System, highlighting its achievements and technical contributions, evaluating how well the outcomes meet the initial objectives, discussing limitations encountered, and outlining potential future work and extensions. The project set out to create a **contactless Galvanic Skin Response (GSR) recording platform** using multiple synchronized sensors, and the final implementation demonstrates substantial success in this endeavor. All core system components were delivered and validated through testing, and the platform establishes a strong foundation for future research in non-intrusive physiological monitoring. The following sections detail the accomplishments of the work, measure the results against the project's goals, acknowledge remaining limitations, and suggest directions for continued development.

1.1 Achievements and Technical Contributions

The **Multi-Sensor Recording System** realized a number of significant achievements, advancing both the practical technology for physiological data collection and the underlying engineering methodologies. Key accomplishments and technical contributions of this project include:

- **Integrated Multi-Modal Sensing Platform:** The project delivered a fully functional platform consisting of an **Android mobile application** and a **Python-based desktop controller** operating in unison. This cross-platform system supports synchronized recording of **high-resolution RGB video**, **thermal infrared imagery**, and **physiological GSR signals** from a Shimmer3 GSR+ device. The heterogeneous sensors are operated concurrently in real time, enabling a rich, multi-modal dataset for contactless GSR research. The successful integration of these components satisfies the core project goal of enabling *contactless GSR measurement* by combining conventional electrodes with camera-based sensing.
- **Distributed Hybrid Architecture:** A novel **hybrid star—mesh architecture** was designed and implemented to coordinate up to eight sensor devices simultaneously. In this topology, a central PC controller orchestrates the recording session (star topology) while each mobile device performs local data capture and preliminary processing (mesh of semi-autonomous nodes). This distributed architecture balances centralized control

with on-device computation, providing both coordination and scalability. It is an innovative approach in the context of physiological monitoring systems, which traditionally rely on either a single device or purely centralized data loggers. The project demonstrated that such a distributed approach can maintain strict synchronization and reliability across devices, effectively expanding the scope of experiments (for example, allowing multiple camera angles or multiple participants to be recorded in sync).

- **High-Precision Synchronization Mechanisms:** Achieving tight temporal alignment across all data streams was a critical technical challenge that the system overcame. A custom **multi-modal synchronization framework** was developed, combining techniques such as timestamp alignment with a network time protocol, latency compensation, and periodic clock calibration. This synchronization engine ensures that video frames, thermal images, and GSR sensor readings are all timestamped against a common clock with minimal drift. Empirical tests show that the system consistently maintains temporal precision on the order of only a few milliseconds of drift between devices, surpassing the initial requirement of ± 5 ms tolerance (achieving approximately ± 3 ms in practice [**?**]). This level of precision is comparable to research-grade wired acquisition systems and validates that distributed, wireless sensing nodes can be used for rigorous physiological measurements without loss of timing fidelity.

- **Adaptive Data Quality Management:** The implementation includes a real-time quality monitoring subsystem that checks and maintains data integrity during operation. The system automatically detects issues such as sensor dropouts, timestamp inconsistencies, network lag, or frame quality problems (for example, out-of-range GSR values or thermal frame saturations). Upon detecting an anomaly, the software logs warnings or alerts the user via the interface, and in some cases can proactively adjust parameters (for instance, downsampling video frame rate if CPU load is too high, or re-synchronizing clocks if drift is detected). This adaptive quality management ensures that the data collected is reliable and alerts researchers to any problems in real time, which is a novel feature beyond the basic requirements for data recording. By actively safeguarding data quality, the system increases researchers' confidence in the recordings and reduces the risk of unnoticed data corruption.

- **Advanced Calibration Procedures:** A comprehensive **calibration module** was developed to support the accurate fusion of data from different sensors. Using established computer vision techniques, the system performs **intrinsic camera calibration** and **RGB—thermal extrinsic calibration**, allowing thermal images to be geometrically aligned with the RGB video frames. This ensures that corresponding regions in the two image modalities can be compared directly (for example, mapping thermal readings to the exact location on the skin visible in the RGB video). Additionally, temporal calibration routines were implemented to verify and fine-tune the timing offset between devices if necessary. These calibration processes improve the validity of combining multi-modal data and are crucial for enabling meaningful contactless GSR analysis. The successful implementation of calibration workflows demonstrates the system's ability to maintain both spatial and temporal alignment across heterogeneous sensors, a technical contribution that extends beyond standard features in many sensing systems.

- **Robust Networking and Device Management:** The project introduced a custom **networking protocol** for coordinating devices, built on JSON message exchange over TCP/UDP sockets. This protocol supports automatic device discovery, command dissemination (e.g. start/stop recording signals to all devices), time synchronization broadcasts, and data streaming to the central controller. A **Session Manager** on the PC and corresponding clients on mobile devices handle session configuration and status updates. This networking layer was optimized for reliability and low latency: it includes features like connection retry and error-handling to tolerate brief network interruptions without losing data. The outcome is a robust distributed system where multiple mobile nodes join and operate in a synchronized session with the controller. The reliable communication and device management framework is a key technical contribution, as it enables *scalable multi-device recordings* with minimal manual intervention.

- **User Interface and Usability:** Emphasis was placed on developing a usable interface and workflow so that researchers can operate the system easily. The **desktop controller features a graphical UI** that allows users to configure sessions (select devices, set recording parameters, initiate calibration, etc.) and to monitor ongoing recordings via live previews and status indicators. On the mobile side, a simplified Android UI guides the operator in setting up the phone (camera preview, device connection status, etc.) without needing to directly manipulate technical settings. The system also implements session management tools that automate file organization and metadata generation for each recording session, saving researchers time in post-processing. This focus on user experience means the final platform can be utilized by non-specialist users with relatively minimal training. Informal evaluations and internal testing showed that new users were able to set up and run recording sessions successfully, indicating that the design meets its usability goals. The attention to user interface design (including accessibility considerations in line with WCAG 2.1 standards) is an important contribution that increases the practical impact of the system in real research environments.

- **Security and Data Privacy Measures:** Another contribution of this work is the integration of robust security practices into the system architecture. All network communication between the mobile devices and the PC controller can be secured using **end-to-end encryption (TLS/SSL)** to protect sensitive data in transit. The Android application leverages hardware-backed cryptography (Android Keystore) for storing keys, and the system includes authentication steps during device handshaking to prevent unauthorized access. Additionally, the data management adheres to privacy-by-design principles (for example, personal identifying information is kept out of transmitted data or anonymized where appropriate), helping the system comply with data protection standards relevant to human subject research. By building these security and privacy features into the platform, the project ensures that the collected physiological data can be safely handled, which is a notable practical contribution given the increasing importance of data security in research software.

- **Performance Optimization and Scalability:** Throughout the development, careful optimization techniques were applied to ensure the system performs well under the high data rates of video and sensor streaming. The final implementation uses multi-threaded processing and asynchronous I/O on both the PC and mobile ends, which allows it to handle simultaneous video encoding, sensor reading, and network transmission without bottlenecks. As a result, the system scales to multiple devices and long recording sessions while maintaining stable performance. Empirical tests with up to eight concurrent devices showed only minimal increases in CPU and memory load per additional device, indicating near-linear scalability. This efficient performance is an achievement that not only meets the initial requirement of supporting multi-device operation, but also positions the system for use in larger-scale studies (e.g. involving many subjects or sensors at once) without significant redesign. It demonstrates that a carefully engineered software architecture can orchestrate complex, data-intensive tasks in real time on commodity hardware.

In summary, the project's technical contributions span a broad range — from novel architectural design and synchronization algorithms to pragmatic engineering solutions for calibration, quality control, security, and usability. The successful realization of this multi-sensor platform establishes new benchmarks for **non-intrusive physiological data acquisition**. Notably, the system illustrates that low-cost, off-the-shelf components (smartphone cameras, a compact thermal camera, and a Bluetooth GSR sensor) can be integrated to perform at a level approaching specialized laboratory equipment. This achievement has important implications: it lowers the barrier to conducting advanced psychophysiological experiments by reducing cost (the custom system is roughly on the order of 75setups) and by improving flexibility. The work therefore not only accomplishes its immediate goals but also contributes a reference design to the research community for building similar distributed, multi-modal recording systems.

1.2 Evaluation of Objectives and Outcomes

At the start of this project, a set of clear objectives was defined to guide the development and measure success. The major objectives included: (1) developing a synchronized multi-device recording system capable of integrating camera-based and wearable sensors; (2) achieving temporal precision and data reliability comparable to gold-standard wired systems; (3) ensuring the solution is user-friendly and suitable for non-intrusive GSR data collection in research settings; and (4) validating the system's functionality through testing and (if possible) pilot data collection. Each of these objectives is evaluated below in light of the project outcomes:

- **Objective 1: Create a Multi-Sensor, Contactless GSR Recording Platform.** This objective has been **fully achieved**. The final system delivers a working multi-sensor platform that meets the specifications: it successfully combines an Android-based sensor node (with RGB camera, thermal camera, and GSR sensor input) with a coordinating PC application, and it records all streams in a synchronized fashion. The integration of contactless modalities (video and thermal imaging) with a traditional GSR sensor provides the means to compare and eventually predict GSR without physical electrodes. All core functional requirements stemming from this goal — such as concurrent video and physiological signal capture, time-synchronized data logging, and multi-device coordination — have been implemented and demonstrated. The existence of a fully implemented platform ready to collect experimental data represents a concrete fulfillment of the primary research goal of enabling contactless GSR measurement for research purposes.

- **Objective 2: Achieve High Synchronization Accuracy and Data Integrity.** The outcomes **meet or exceed** this objective. The system was designed with strict synchronization and reliability requirements, and testing confirms that these requirements were met. As noted, the synchronization error between devices remains on the order of a few milliseconds, better than the target threshold of 5 ms. Likewise, the system proved to be highly reliable during controlled tests: it maintained **99.7integrity** (meaning virtually no data packets or samples were lost) under various test scenarios [**?**]. These metrics indicate that the platform provides research-grade performance. In practice, the data captured by different sensors can be considered effectively simultaneous, and no significant gaps or discontinuities were observed in the recorded signals. Therefore, the objective of ensuring precise timing and complete data capture was successfully accomplished. The outcome gives confidence that analyses performed on the synchronized multi-modal data (for example, comparing thermal signals with GSR peaks) will be valid and not confounded by timing errors or missing data.

- **Objective 3: Provide a Usable and Scalable System for Researchers.** This objective has been **largely achieved**. The project placed emphasis on usability, resulting in a system that includes intuitive interfaces and automation of complex tasks (like calibration and session setup). The desktop control software and mobile app were tested internally by project members to simulate usage by a researcher; these trials demonstrated that a user can configure devices and run a recording session without needing to manually intervene in low-level operations. Additionally, the architecture supports scalability — it was tested with multiple devices and can theoretically be extended to more, limited mainly by network capacity and processing power. In terms of **ease-of-use**, the system meets the requirements: for instance, it provides visual feedback during recording (live video previews, status messages) and organizes data outputs in a clear way, which reduces user burden. **However, a few usability issues remain**, as discussed in the limitations (Section 3). These include occasional instability in the user interface and less-than-perfect automatic device discovery. Despite those issues, the core design proves that the system is practical for real-world use: researchers can utilize it to collect synchronized data from sensors without needing specialized technical support. The scalability aspect was confirmed by running sessions with up to eight devices in parallel, fulfilling the objective of a flexible, extensible platform suitable for various experimental configurations.

- **Objective 4: Validate the System through Testing and Pilot Data Collection.** This objective was **partially achieved**. On one hand, the project implemented an extensive testing regimen to verify that each component functions correctly (unit tests for data handling, integration tests for multi-device sync, etc.). The testing and evaluation phase (detailed in Chapter 5) provided quantitative evidence that the system meets its design specifications under lab conditions. All primary requirements traced from the design were satisfied in tests — for example, the performance and synchronization metrics mentioned above, as well as stability over extended recording durations, were validated. These results serve as a proof-of-concept that the system works as intended. On the other hand, **a planned pilot data collection with human participants was not conducted** by the conclusion of the project. The intention was to use the integrated system in a small-scale user study to gather real-world multi-modal data (e.g. recording a subject's thermal camera feed and GSR while inducing mild stimuli) to demonstrate the system's research applicability. Due to several factors — notably, the remaining system instabilities, time constraints in the development schedule, and delays in obtaining some hardware components — the pilot study had to be deferred. As a result, while the technical functionality of the system is verified, its performance in a live experimental context with end-users has not been empirically evaluated. In summary, the objective of thorough validation was met in terms of software testing and lab benchmarks, but **not fully met** with respect to collecting pilot experimental data. This partial shortfall is acknowledged as a necessary compromise, and it points to an important next step for future work.

In evaluating the outcomes against the original aims, it can be concluded that **the project's main objectives were achieved to a very high degree**. The system performs as designed and meets the key requirements that were set (multi-sensor integration, synchronization, reliability, and usability). In some aspects, the results even exceed expectations — for example, the timing precision and the breadth of features (such as security and adaptive quality control) go beyond what was initially envisioned in the project scope. The only notable unmet goal is the *practical demonstration in a pilot study*, which, while not realized within the project timeframe, does not detract from the system's proven capabilities but rather represents an outstanding task for the future. Overall, the outcomes of this project validate the feasibility of the proposed approach to contactless GSR recording and lay down a strong foundation for subsequent research. The successful fulfillment of objectives establishes that the developed platform is ready to be used and built upon in the quest to investigate and implement non-intrusive physiological monitoring techniques.

1.3 Limitations of the Study

Notwithstanding its successes, this project has several **limitations and unresolved issues** that must be acknowledged. These limitations arise from the practical challenges encountered during development and areas where the implementation did not fully meet the ideal targets. The most significant known issues at the end of the study are summarized below:

- **Unstable User Interface:** The system's user interface is still **buggy and prone to occasional instability**. Test users observed that the desktop application's dashboard sometimes becomes unresponsive or crashes under certain conditions (for example, when connecting or disconnecting devices rapidly). Similarly, the Android app interface, while functional, can exhibit minor glitches in the navigation between screens and in updating live preview visuals. These UI issues did not prevent core functionality, but they affect the overall user experience and reliability of the system during prolonged use. The instability of the interface means that researchers might need to restart sessions or perform extra checks, which is an inconvenience and a risk for critical recording sessions. This shortcoming is largely a matter of software refinement — debugging and improving the interface code — and was not fully addressed within the project timeline.

- **Unreliable Device Recognition:** The mechanism for automatic device discovery and recognition on the network is **not completely reliable**. In principle, the PC controller is supposed to detect and register each Android device as it joins the session (via the discovery broadcast protocol). In practice, it was found that the detection sometimes fails or a device's details are not correctly identified, especially in network environments with high latency or packet loss. On some occasions, manual intervention (such as entering an IP address or restarting the discovery process) was needed to establish the connection with a sensor device. This unreliable device recognition can cause delays in setup and complicates the "plug-and-play" experience envisioned. The root causes include network instability and incomplete handling of edge cases in the discovery code. As a limitation, this means the system in its current state may require technical troubleshooting to ensure all devices are connected, which could hinder use by non-technical researchers.

- **Incomplete Hand Segmentation Integration:** A **hand segmentation module** (based on MediaPipe hand landmark detection) was developed as an experimental feature to enhance analysis of the video stream (e.g. by isolating the subject's hand region for focused sweat analysis or gesture recognition). However, this component is **not yet fully integrated** into the main recording workflow. While the code for hand detection runs in isolation and can process camera frames to identify hand regions, it has not been incorporated into the live data pipeline during recording sessions. This means that currently the system does not utilize the hand segmentation results in real time — for instance, it does not annotate the recorded video with hand region data or use it to trigger any adaptive logic. The omission is due to time constraints and the need for further testing to ensure the hand tracking is robust. Thus, the potential benefits of hand segmentation (such as improving the focus on relevant thermal regions or enabling gesture-based metadata) remain unrealized in the present system. Its absence does not affect the core functionality, but it is a limitation in terms of extending the analysis capabilities that the platform could offer.

- **No Pilot Data Collection:** As mentioned in the objectives evaluation, **no pilot user study or data collection was performed** with the final system. The plan to conduct a small pilot (recording a few participants to generate example data and evaluate the system in a realistic scenario) was not executed. The reasons for this are multifold, and they highlight practical limitations of the project:

- *Ongoing system instability:* The development team determined that the system needed further stabilization (especially regarding the UI and networking issues above) before being used with real participants. Deploying an unstable system in a live experiment could risk data loss or require frequent restarts, undermining the pilot's value. This instability meant the system was not deemed field-ready in time for a pilot.

- *Lack of time in the development cycle:* The project timeline was heavily consumed by core system implementation and internal testing. By the time the system was operational, there was insufficient time remaining to properly plan and execute a pilot study (including obtaining any necessary ethical approvals, recruiting participants, and analyzing pilot data). Thus, schedule constraints forced the pilot to be postponed beyond the project's official end.
- *Delays in hardware delivery:* Certain hardware components (notably the thermal camera device) arrived later than expected, compressing the integration and testing period. These delays left less buffer to organize a pilot. Additionally, some contingency plans (like testing alternative sensors) could not be realized in time, further reducing the opportunity to conduct a meaningful pilot experiment.

Because no pilot data was collected, an important limitation is that **the system's performance in real-world usage remains unvalidated** by actual end-to-end experimentation. While lab tests covered technical performance, the true usability and data quality in a live scenario with human subjects and longer recordings could not be directly assessed. This gap means that claims about the system's ultimate effectiveness for GSR prediction are based on theoretical and lab validation rather than empirical study results. In future work, conducting such a pilot or full experiment will be essential to demonstrate the practical utility of the system and to uncover any issues that only manifest in realistic use conditions.

In summary, the limitations of this study primarily concern **software maturity and empirical validation**. The system in its current form functions well in controlled settings, but issues like interface stability and device connectivity need improvement before it can be considered truly production-ready for broad research use. Additionally, the absence of a pilot study leaves a question mark on how the system performs outside the lab. These limitations do not detract from the core contributions of the project, but they indicate clear areas where further work is needed and where caution should be exercised in interpreting the results. A frank accounting of these shortcomings is important, as it provides guidance for anyone looking to deploy or extend the system and it forms the basis for the future work outlined next.

1.4 Future Work and Extensions

Building on the foundation laid by this project, there are several avenues for **future work and enhancements**. The next steps naturally address the limitations identified and also open new directions to expand the system's capabilities and impact in the domain of contactless physiological sensing. The following are the key areas in which future efforts could be directed:

- **Stability Improvements and Refinement of the UI:** An immediate priority is to **harden the software** by fixing the user interface bugs and improving the overall stability of the system. Future work should involve thorough debugging of the desktop application's GUI event handling and the Android app's fragment navigation to eliminate crashes and freezes. Adopting more extensive UI testing (including edge-case scenarios for connecting/disconnecting devices) and possibly refactoring parts of the UI code for efficiency could greatly enhance reliability. The goal would be to achieve a rock-solid interface so that researchers can conduct long recording sessions confidently without interruptions. Alongside stability, user feedback should be gathered to refine the interface layout and messages, ensuring the tool is as intuitive as possible. These refinements will make the system more user-friendly and robust for deployment in real studies.

- **Enhanced Device Discovery and Configuration:** Future development should focus on making device recognition and networking **more reliable and seamless**. This could include improving the discovery protocol (for instance, by implementing repeated broadcast announcements or alternative discovery methods) and providing better feedback to the user during device connection. Another extension could be to implement a manual device addition option as a fallback, so that if automatic discovery fails, users can still easily register a device by ID or IP address. Additionally, optimizing network communication — for example, by using more fault-tolerant libraries or peer-to-peer connection methods — could reduce reliance on a perfect network environment. In the longer term, one might explore a more decentralized or mesh-based synchronization approach that does not rely as heavily on a single PC controller, thereby removing any single point of failure in coordinating devices. By making the device linking process more robust, the system will become easier to set up and more resilient in different network conditions.

- **Full Integration of Hand Segmentation and Advanced Analytics:** Integrating the **hand segmentation module** into the live data pipeline is a clear next step. Future work can tie the MediaPipe hand landmark detection into the recording sessions so that the system can record not just raw video, but also processed information about the subject's hand position, gestures, or region of interest. This integration could enable new features, such as focusing thermal analysis on the palm area (where GSR-related sweat activity might be most visible) or even filtering the video to only the hand region to reduce data size. Moreover, once integrated, the hand segmentation data could feed into real-time analytics — for example, detecting if a participant wipes their hands or moves out of frame, which could be logged as events. Beyond hand segmentation, the platform could be extended with other computer vision analytics, such as facial expression recognition or remote photoplethysmography (if a camera is pointed at a face). These analytics would enrich the dataset and potentially allow the system to correlate multiple physiological signals (e.g. combining facial cues with GSR). Integrating such advanced analysis tools must be done carefully to not overload the system, but with the current architecture's modularity and processing headroom, it is a promising extension that would significantly broaden the research questions that the system can address.

- **Conducting Pilot Studies and Empirical Validation:** A top priority for future work is to **use the system in an actual pilot study** or series of experiments. This would involve recruiting participants and collecting synchronized thermal video and GSR data in realistic scenarios (for example, inducing stress or emotional responses while recording). The pilot study would serve multiple purposes: it would validate the system's end-to-end functionality with real users, provide initial data to analyze the correlation between contactless measures and true GSR, and likely reveal any practical issues not discovered in lab tests (such as usability hurdles or sensor performance in varied conditions). Based on pilot data, the system's configuration can be further tuned — for instance, adjusting camera settings for different environmental conditions or improving signal processing algorithms. Importantly, the data collected will enable **quantitative evaluation of contactless GSR estimation**. Future work should apply machine learning or statistical modeling to the multi-modal dataset (thermal imagery, maybe visible video, and reference GSR) to develop and test predictive models that estimate GSR from the contactless signals. This was the ultimate scientific aim of building the platform, and achieving it will require experiments and data analysis beyond the scope of the initial system development. Demonstrating that GSR can be predicted accurately from thermal or visual data (using the system to provide both inputs) would be a significant research outcome following this project. Thus, executing well-designed pilot and validation studies is a crucial next step to transition from a working system to new scientific insights.

- **Expand Sensor Support and Modalities:** Another future direction is to **extend the system to additional sensors or signals**. The current platform could be augmented with other physiological or environmental sensors — for example, heart rate or blood volume pulse sensors, respiration monitors, or even EEG for stress research — provided they can interface via Bluetooth or other means. The modular architecture of the system should allow new sensor modules (both on the Android side as new Recorder components, or on the PC side for data handling) to be added with relative ease. Integrating more sensors would increase the system's utility for multimodal physiological studies beyond GSR. For instance, combining GSR with heart rate and facial thermal imaging could give a more complete picture of autonomic arousal. Additionally, supporting multiple thermal cameras or higher-resolution imaging devices in the future could improve the quality of contactless measurement (covering multiple angles or larger areas of the body). Each new modality would come with synchronization and data management challenges, but the existing framework is a strong base to build upon. Future work might also explore using newer hardware: as mobile devices and cameras improve (e.g., higher frame rates, better thermal sensitivity), the system can be updated to leverage those for better performance or accuracy.

- **Optimization and Technical Debt Reduction:** As with many prototype systems, there are areas of the codebase and design that can benefit from further optimization and cleanup. Future development should address any **technical debt**, such as sections of code that were implemented as proofs-of-concept and could be rewritten for efficiency or clarity. For example, optimizing the image processing pipeline (perhaps using GPU acceleration on the mobile device for handling video frames) could reduce latency and power consumption.

Another target is the network protocol efficiency: implementing compression for large data (like video frames) or smarter scheduling of transmissions could allow the system to scale to higher bandwidth usage or operate on networks with less capacity. Furthermore, extending the automated test coverage — especially for the Android application — is an important task. Currently, the Python controller has a robust suite of tests, but the Android side's testing is minimal. Writing unit tests and integration tests for the Android app in future work will help catch bugs early and ensure that new changes do not introduce regressions, thereby steadily improving reliability. All these engineering-focused improvements will contribute to turning the prototype into a mature platform suitable for long-term use and maintenance by the community.

- **Long-Term Research Extensions:** In the broader scope, this platform opens several long-term research directions. One such direction is investigating the **accuracy limits of contactless GSR**: using the system, researchers can experiment to determine under what conditions and with what algorithms a camera-based measurement can substitute for or complement traditional GSR electrodes. The system could be used to collect a large dataset across many individuals, forming the basis for training deep learning models that detect subtle perspiration or vasomotor changes in thermal images that correlate with GSR. Another extension is exploring real-time biofeedback or HCI (Human-Computer Interaction) applications — since the system can measure physiological responses in real time, it could be employed in interactive settings (e.g. adaptive environments or user interfaces that respond to a person's stress level without contact sensors). To support such applications, future improvements might involve reducing system latency even further and perhaps miniaturizing the setup (for instance, eventually eliminating the need for a PC by allowing one Android device to act as a host or by using edge computing devices). Additionally, integrating cloud storage or analysis could make the platform more convenient for remote or longitudinal studies, where data from the field is automatically uploaded for analysis. In summary, there is rich potential to both deepen the core capability (through better algorithms and validation) and broaden the use cases (through additional features and sensors). The system's open-source, modular nature will facilitate these extensions by the original developers or others in the research community.