Czech University of Technology in Prague

SOFTWARE

Software for recording and evaluating the fitness of military and IZS members

TM05000017-V4

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Result language: CZE

Main field: JB - Sensors, sensors, measurement and control

Applied: YES

Result name in Czech:
Software for recording and evaluating the fitness of military and IZS members

Result name in English:
Software for recording and evaluating the condition of members of the army and first responders

Abstract of the result in Czech: The result is a specialized measurement and analytical application designed for the collection, integration and evaluation of multimodal time series related to physical activity and physiological response of members of the army and IRS units.
The key principle is a unified data layer based on InfluxDB, which unifies data streams from different sources (image data, inertial sensors, ECG, stabilometry) into a common timeline. The application allows for storage, retrieval, export and reproducible evaluation. The application supports real-time visualization mode for operational control of measurement integrity and offline analysis mode for retrospective inspection and data validation. The camera recording part integrates the MediaPipe Pose model for body posture estimation. The result of each measurement is a database-stored session identified by the session_id tag, which serves as a unified source for export to CSV and for internal offline analysis directly in the application. The software provides a unified platform for collecting, controlling and evaluating heterogeneous data streams, which enables the creation of validated data sets and supports decision-making in the area of users' physical fitness and health status.

Abstract of the result in English:

The result is a specialized acquisition and analysis application designed for the collection, integration, and evaluation of multimodal time-series data related to movement activity and physiological responses of members of the army and first responders. The key principle is a unified data layer based on InfluxDB, which consolidates data streams from various sources (image data, inertial sensors, ECG, stabilometers) into a common timeline. The application enables storage, retrieval, export, and reproducible evaluation of data. It supports a real-time visualization mode for operational integrity checks during

measurement and an offline analysis mode for post hoc inspection and validation. In the camera-based branch, the MediaPipe Pose model is integrated for estimating body posture. Each measurement results in a database-stored session identified by a session_id tag, serving as a unified source for CSV export as well as for internal offline analysis within the application. The software provides a consolidated platform for the collection, monitoring, and evaluation of heterogeneous data streams, enabling the creation of validated datasets and supporting decision-making regarding users' physical fitness and health status.

Keywords in Czech:

multimodal measurement, time series, stabilometry, posture, data analysis

Keywords in English:
multimodal measurement, time series, stabilometry, posture, data analysis

Owner of the result:
Czech Technical University in Prague (Company ID 68407700) - 100%,

Location: CTU

License: No

License fee: No

Economic parameters:

Cost category: cost amount ÿ CZK 10 million.

Result description

The result is a desktop measurement and analysis application designed for the collection, integration and subsequent inspection of multimodal time series related to movement activity and physiological response. The software unifies heterogeneous data streams (image data for calculating the position of body segments, inertial and ECG signals and stabilometric data) into a single data layer based on the InfluxDB time series database. The application supports real-time collection integrity control (connection diagnostics, continuous signal visualization, 3D reconstruction control) and offline analysis mode, in which sessions identified by the session_id key are retrieved from the database and visualized for evaluation and validation.

Abstract (CZ)

The result is a specialized measurement and analysis application for multimodal collection and offline analysis of time series related to physical activity. The key principle is a unified data layer built on InfluxDB, which unifies asynchronous data streams into a common timeline and enables auditable storage, repeated querying, export and reproducible evaluation. The application is implemented in Python 3.10 with a Qt graphical interface (PySide6) and a multi-threaded architecture. The image branch integrates the MediaPipe Pose model for extraction of key body points and optionally 3D triangulation after stereo calibration. In real-time mode, the visualization is primarily used for operational control of measurement integrity. The final output is a database-stored session marked with session_id, usable for export to CSV and for internal offline analysis in the application.

Abstract (EN)

The result is a specialized acquisition and analysis application for multimodal data collection and offline analysis of time-series data related to movement activity. The key principle is a unified data layer based on InfluxDB, which consolidates asynchronous data streams into a common timeline and enables auditable storage, repeated querying, export, and reproducible evaluation. The application is implemented in Python 3.10 with a Qt (PySide6) graphical user interface and a multithreaded architecture. In the vision branch, the MediaPipe Pose model is integrated for extracting body keypoints, and optional 3D triangulation is supported following stereo calibration. In real-time mode, visualization primarily serves for operational integrity checks of the measurement. The final output is a database-stored session identified by session_id, which can be used for CSV export as well as for internal offline analysis within the application.

Keywords (CZ)

multimodal measurement; time series; InfluxDB; real-time visualization; offline analysis; MediaPipe Pose; 3D triangulation; CoP; ECG; IMU

Keywords (EN)

multimodal measurement; time series; InfluxDB; real-time visualization; offline analysis; MediaPipe Pose; 3D triangulation; Braid; ECG; IMU

Technical parameters

- System type: desktop measurement and analysis application for collection, storage, visualization and offline inspection of multimodal time series
- Programming language: Python 3.10

- GUI: Qt / PySide6
- Architecture: multi-threaded (MainWindow + Workers), signals/slots for integration into GUI
- Image processing: pipeline with MediaPipe Pose, optionally 3D triangulation after stereo calibration
- Data layer: InfluxDB (time series, querying, exporting, session retrieval)
- Session identification: session_id tag shared across measurements
- Supported OS: Windows 10/11 (64-bit)
- Outputs: InfluxDB sessions, real-time and offline visualization, CSV export via Data Explorer

1. Characteristics and purpose of the software

The application is a software platform designed for integrating heterogeneous time series into a single, auditable data model and for their subsequent inspection. From the data lifecycle perspective, the system is built on three interconnected layers: 1. an acquisition layer implemented by concurrent work threads, 2. an integration data layer based on InfluxDB, and 3. a presentation-analytical layer that provides real-time integrity control and subsequently an offline mode for retrospective evaluation.

The key unifying element is the measurement session identified by the session_id tag. This identifier is used across modalities and allows for the unambiguous binding of records from different data streams into a single closed session that can be repeatedly queried, exported, and analyzed without the need for manual matching of data files.

2. Typical usage scenario

The operational scenario of working with the software is divided into the collection phase and the subsequent evaluation phase. In the measurement mode, the emphasis is placed on verifying the readiness of the data layer, diagnosing connected data sources and continuously checking signals. Real-time visualization is understood as a tool for operational validation of data integrity (flow continuity, absence of obvious artifacts, consistent behavior of individual modalities). After the measurement is completed, the result is a database-stored session (session_id), which represents a single source for exporting raw time series to external analytical tools and simultaneously for internal offline analysis in the application.

Fig. 1: Main application window (Body Sensors tab). The interface is divided into three logical blocks: (1) Left control panel "Device Control", (2) Graphic part for visualization of acceleration and ECG, (3) Bottom part for camera preview.

3. Software architecture and implementation

The application is implemented in Python 3.10 and uses Qt (PySide6) to create a desktop GUI. Due to the requirement for concurrent acquisition from asynchronous sources with different sampling rates, the architecture is designed as multi-threaded. The central role is played by the MainWindow class, which acts as the application lifecycle controller and the integration point for visualization. Partial acquisition and processing functions are implemented by worker threads (Workers), which separate real-time acquisition from the GUI and minimize the risk of interface blocking.

A database management object (DBManager) in the form of a shared instance is used for uniform access to the data layer. This option allows consistent work of all parts of the system with a single database connection, a uniform session model, and a uniform convention for writing to time series.

Machine Translated by Google

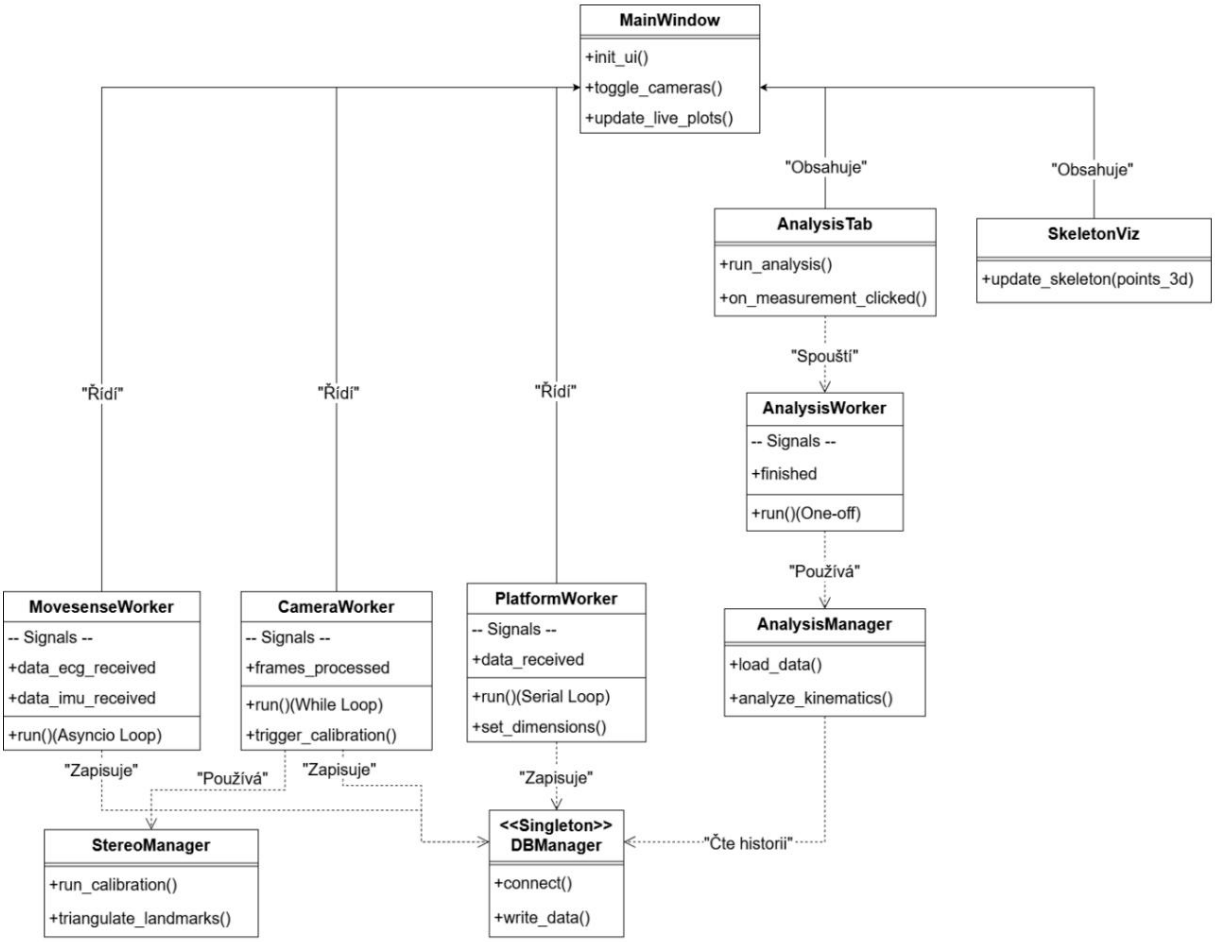

Fig. 2: Class diagram showing the application architecture. The main window (MainWindow) controls individual worker threads that use shared classes and write data to the database.

3.1 Image processing, pose estimation and 3D triangulation

The image branch of the application implements a real-time image processing pipeline, which aims to obtain the position of body segments in the form of anatomical points and store this representation as a time series. To extract these anatomical points, the MediaPipe Pose model is integrated, which provides a set of "keypoints" usable for visual inspection and subsequent offline processing.

Optionally, the fusion of two synchronous image streams into 3D space using 3D triangulation is supported. This part is conditional on the performance of stereo calibration. The software continuously displays the progress of the calibration, its quality and the control of the resulting 3D reconstruction. From the point of view of subsequent evaluation, it is essential that any systematic calibration error is reflected in the geometry of the 3D skeleton and subsequently in the derived kinematic quantities.

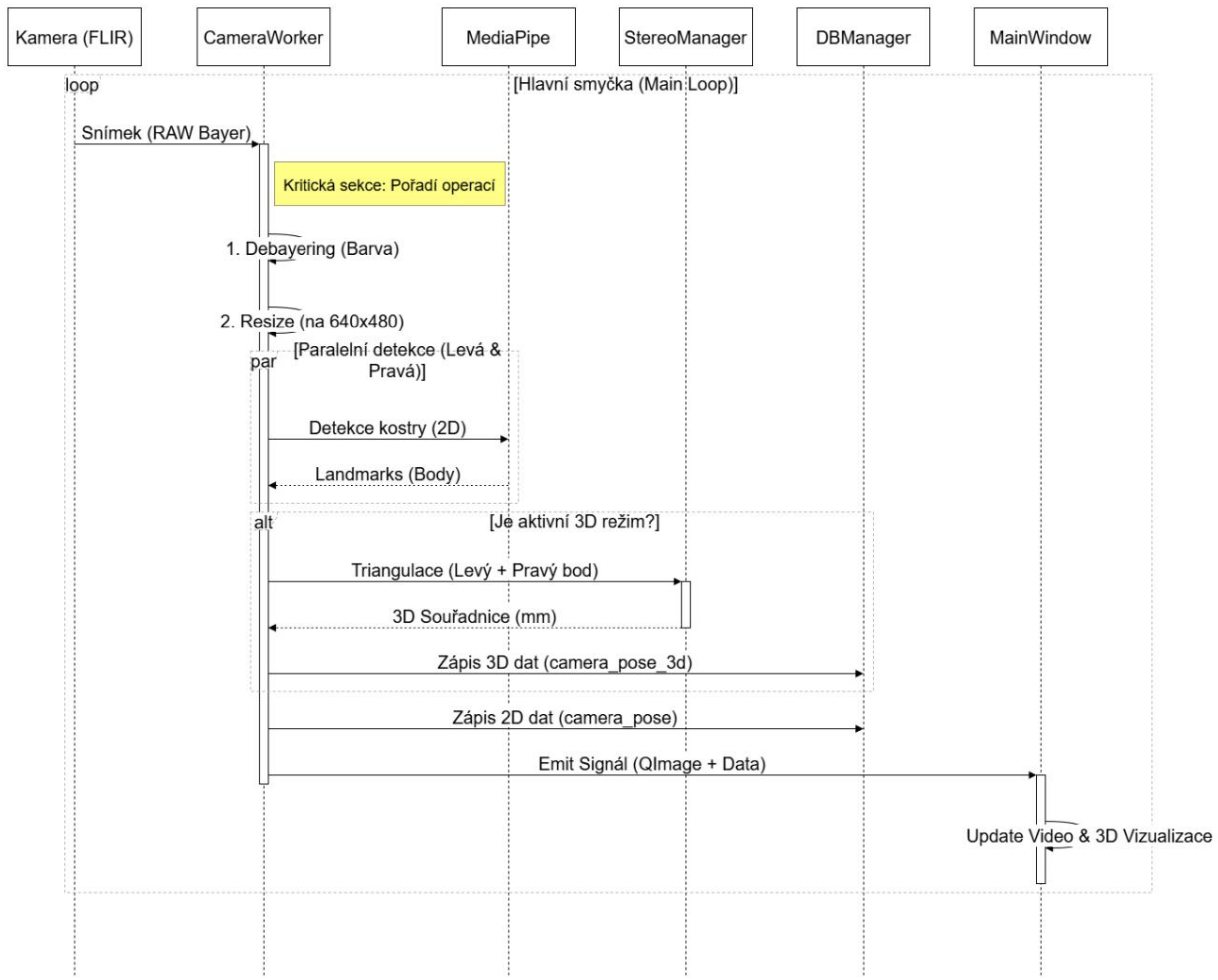

Fig. 3: Camera pipeline. RAW image acquisition ÿ Debayering ÿ AI Detection (MediaPipe) ÿ 3D Triangulation ÿ Writing to DB.

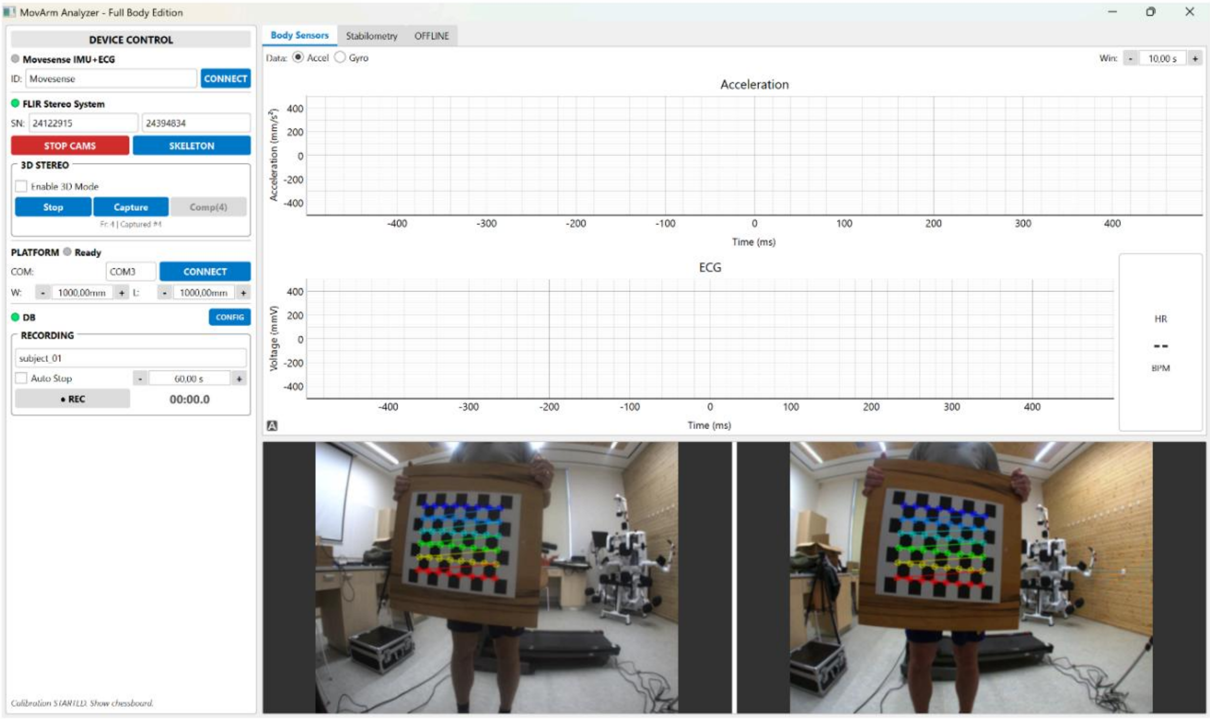

Fig. 4: Calibration process. The system detects the inner corners of the chessboard (colored connecting lines) in real time. For a quality result, it is necessary to record images from different angles and distances.

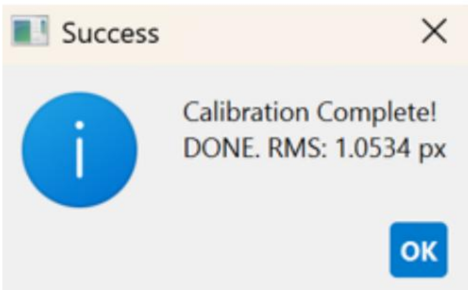

Fig. 5: Successful completion of calibration. The system reports an RMS error of 1.05 px, which is an acceptable value for accurate measurement.

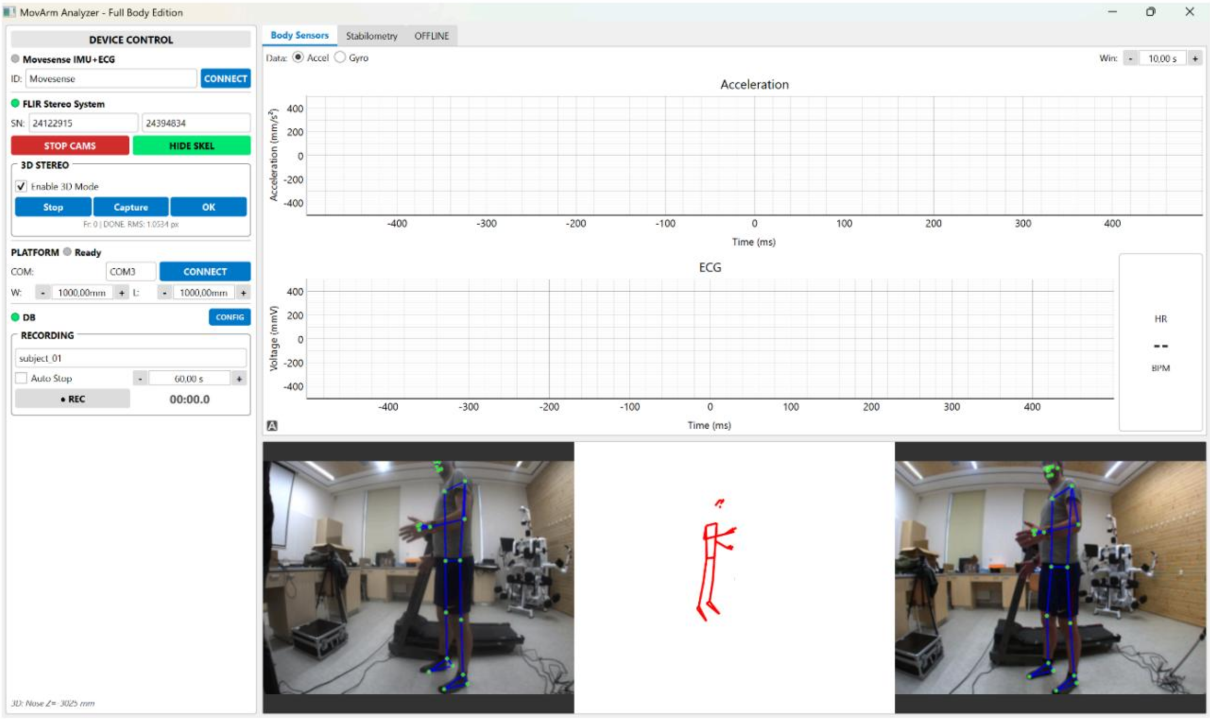

Fig. 6: Checking the 3D model (middle). If the calibration is correct, the software reconstructs the movement of the measured subject in real time into a 3D skeleton.

3.2 Integration of asynchronous data streams

The acquisition layer is designed to integrate data streams with different characteristics (frequency, format, transmission). Individual Workers work independently, providing data parsing and writing time series to InfluxDB with a timestamp so that later consistent queries and signal overlays can be performed offline. The system does not enforce a uniform sampling rate, but works with the natural frequency of individual sources. Temporal coherence is ensured through the data layer and subsequent queries.

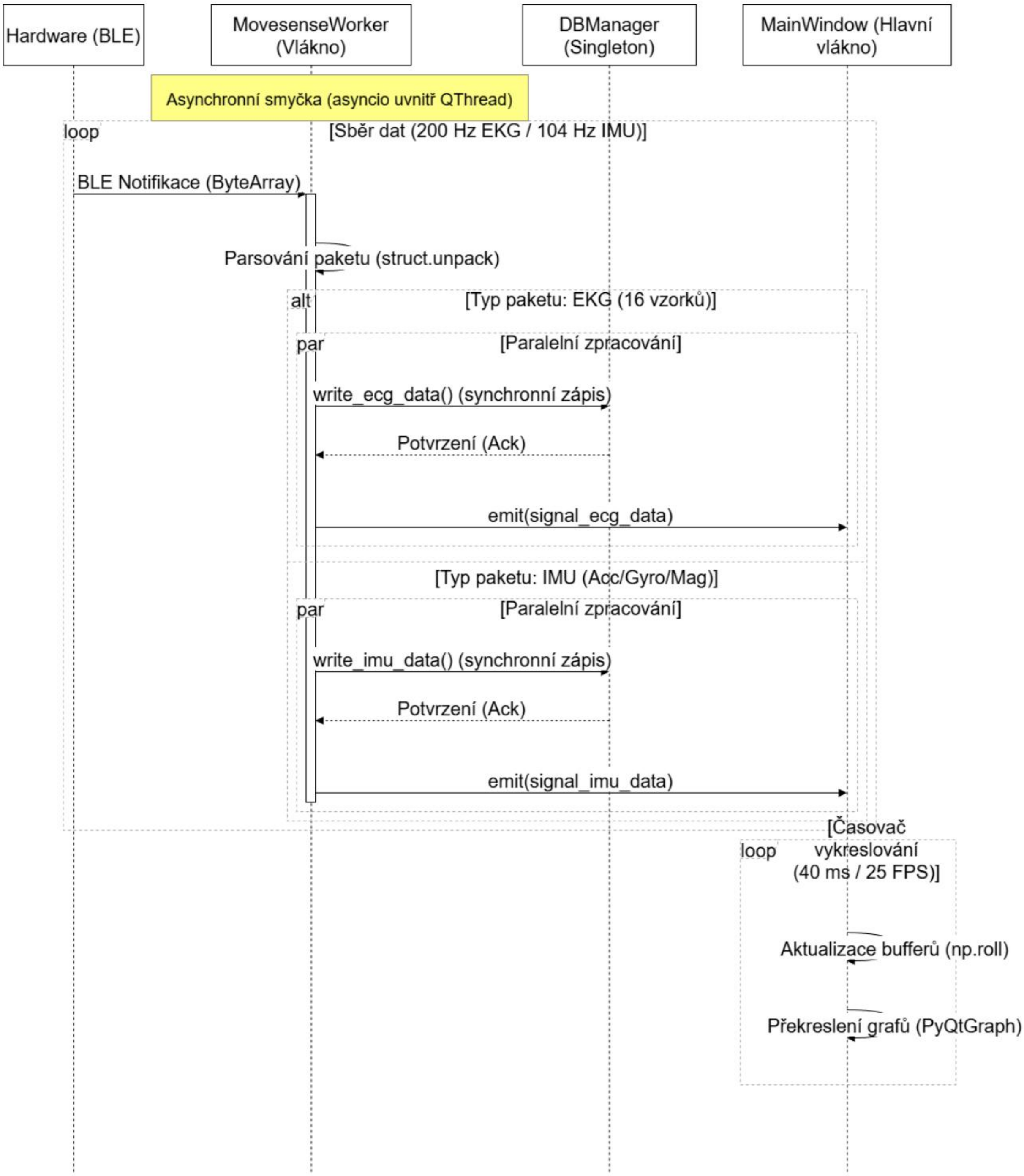

Fig. 7: Pipeline communication with ECG/IMU sensor. The thread receives binary data, performs its parsing and branches logic according to packet type (ECG vs. IMU) before parallel writing to the database and sending to the GUI.

4. Data Layer and Session Management (InfluxDB)

The data layer unifies heterogeneous data streams into a common timeline and ensures reproducible work with data after the measurement is completed. InfluxDB plays the role of an integration component that enables uniform session identification, efficient querying over time series, standardized export of raw data for external processing, and subsequent internal offline analysis directly in the application.

4.1 Database model and session identification

The data model is organized into Measurements by data source type. Across all measurements, a session is tied together by a session_id tag. This ensures that a session can be viewed as a consistent set of time series that can be queried and visualized together.

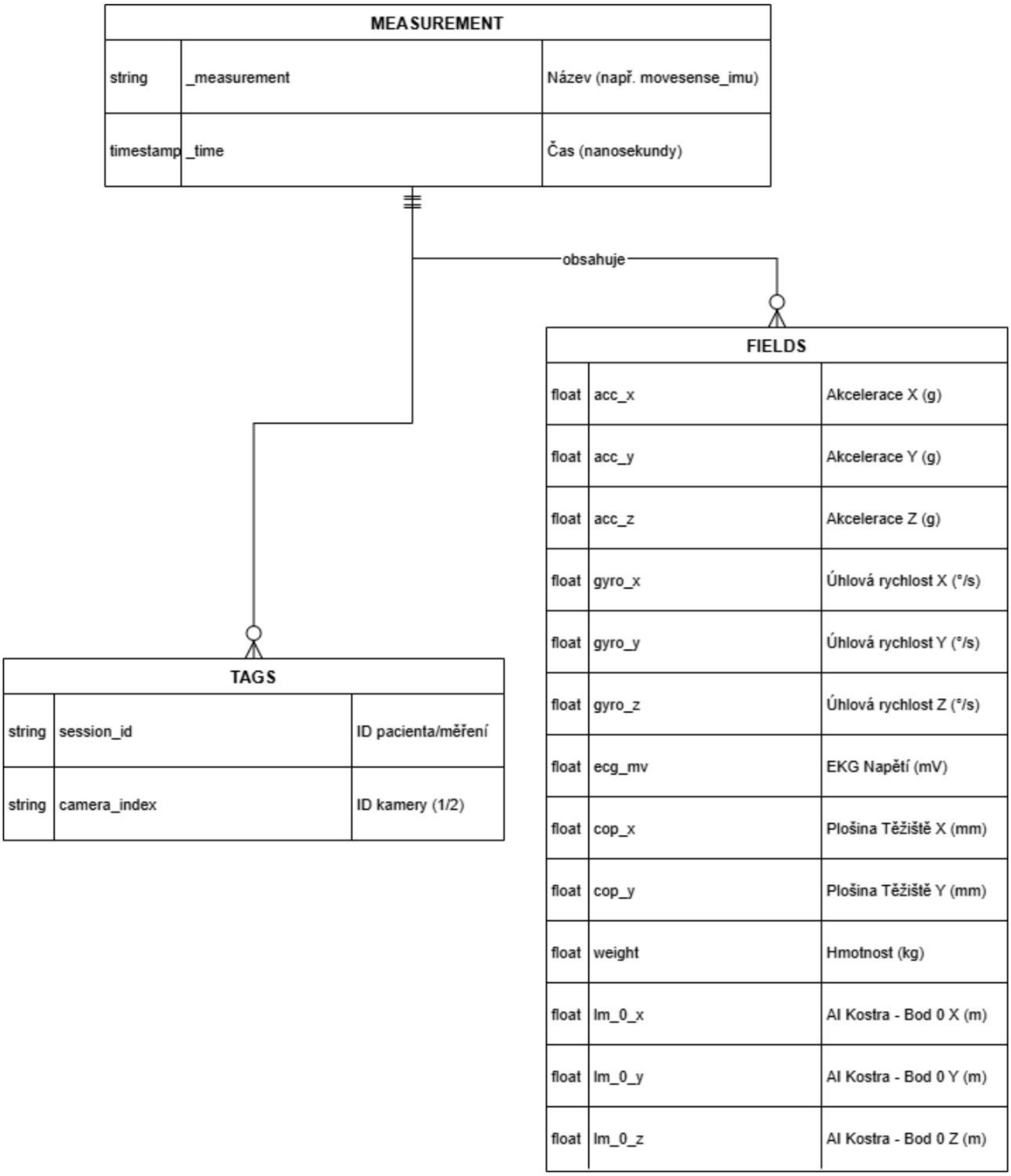

Fig. 8: Database schema. Defines the structure of measurements, tags, and fields stored in the time series.

4.2 Database service operation and application connection

The application assumes the availability of the database service during data collection and in the subsequent offline analysis phase. The connection is implemented through a configuration dialog, in which the parameters for accessing the database are defined. The application checks the availability and indicates the status connections. The database layer is therefore understood as a key component ensuring auditability and reproducibility of sessions.

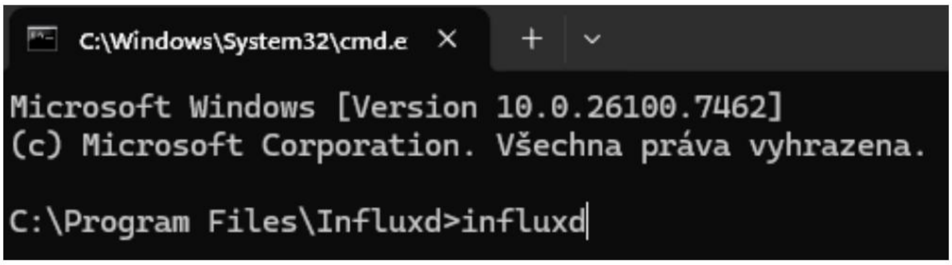

Fig. 9: Starting the InfluxDB server in the command line (cmd) with the influxd command.

Fig. 10: Running InfluxDB server: log output in cmd confirms active operation of the database service.

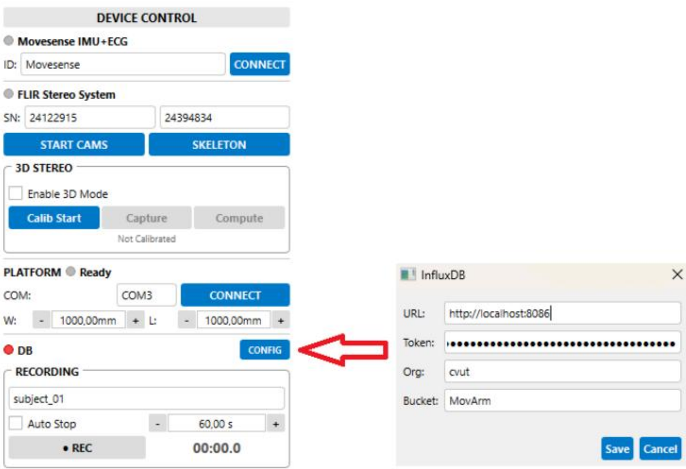

Fig. 11: Database connection configuration. Clicking the CONFIG button in the main panel opens a window for entering access data (URL, Token, Org, Bucket).

4.3 Data export (Data Explorer, CSV)

The data model stored in InfluxDB enables standardized transfer of raw time series to external analytical tools without intervention in the application. The export is performed based on query over the selected measurement and session defined by session_id, which ensures that the exported The CSV file corresponds to one closed session and is consistent across the selected variables.

Fig. 12: InfluxDB Data Explorer interface. It is used for detailed querying of data. In the lower part (Query Builder), specific sensors and quantities are selected. The CSV button is used to export data to a file.

5. User interface and data visualization (real-time)

The user interface is designed as an operator workstation that focuses on diagnostics of the status of connected data sources, continuous control of measured quantities, and image preview.

Real-time visualization is not intended as a final interpretation, but as a tool for operational validation of the integrity of the collection: it allows you to identify transmission failures, obvious signal artifacts or inconsistency of data streams over time. The final result of the measurement is a session stored in InfluxDB (session_id), which serves as a single source for export and offline analysis.

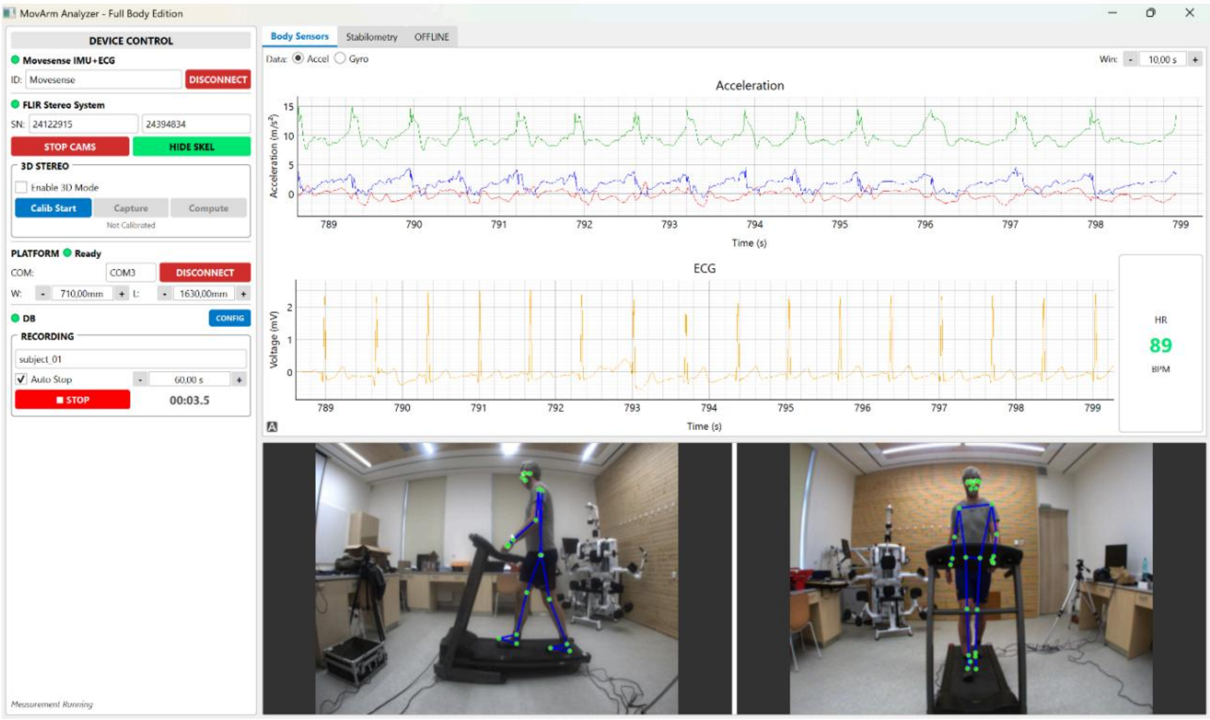

Fig. 13: Application in active measurement mode. When connected successfully, all devices in the left panel are green. The record button has changed color to red (STOP) and the timer is counting down the recording duration. The graph shows live data from the accelerometer and ECG.

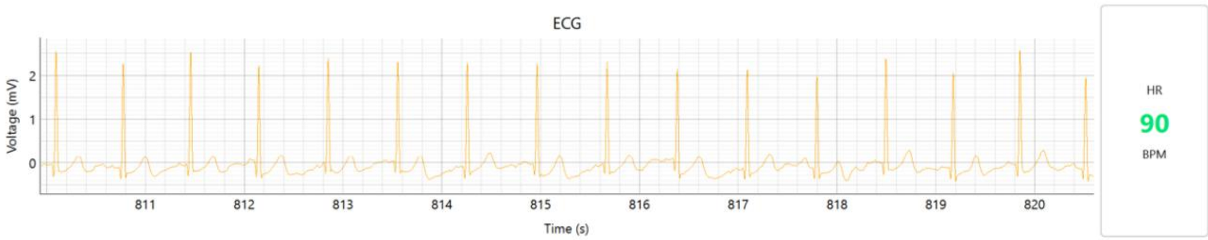

Fig. 14: Detail of ECG signal check. The correct condition shows a clean waveform and a real heart rate value.

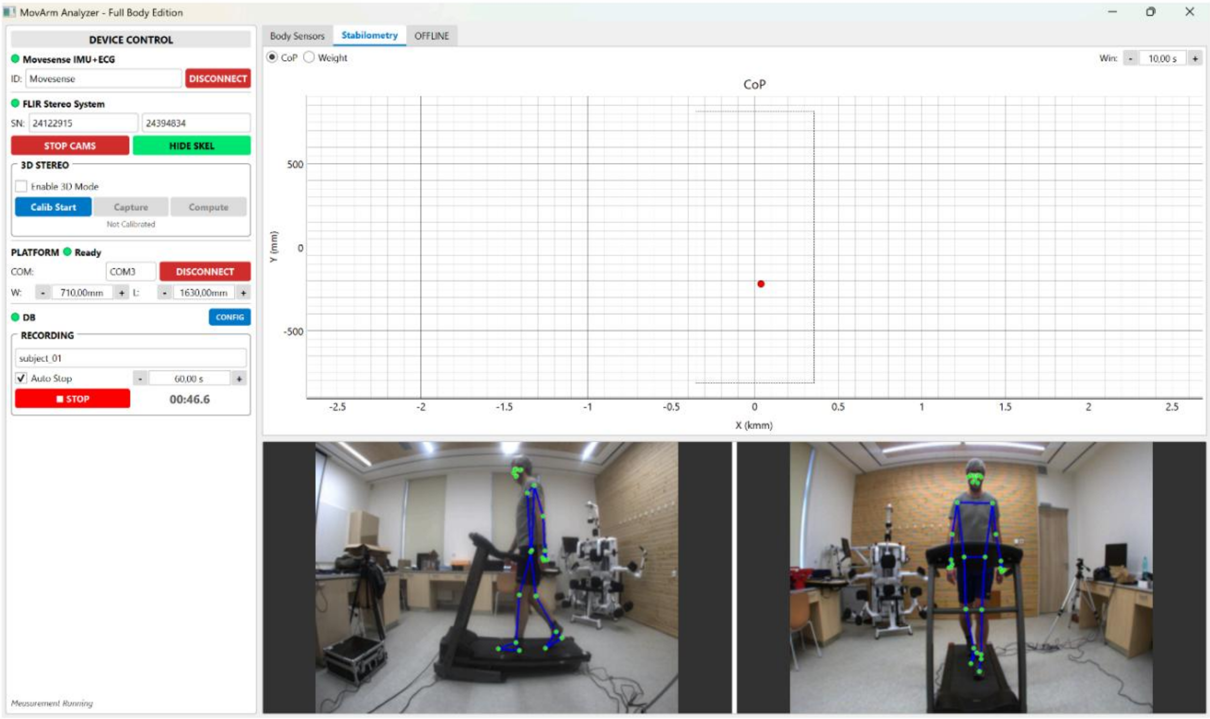

Fig. 15: CoP visualization (Stabilometry). The graph shows the weight distribution on the platform. The center of coordinates (0,0) corresponds to the geometric center of the platform.

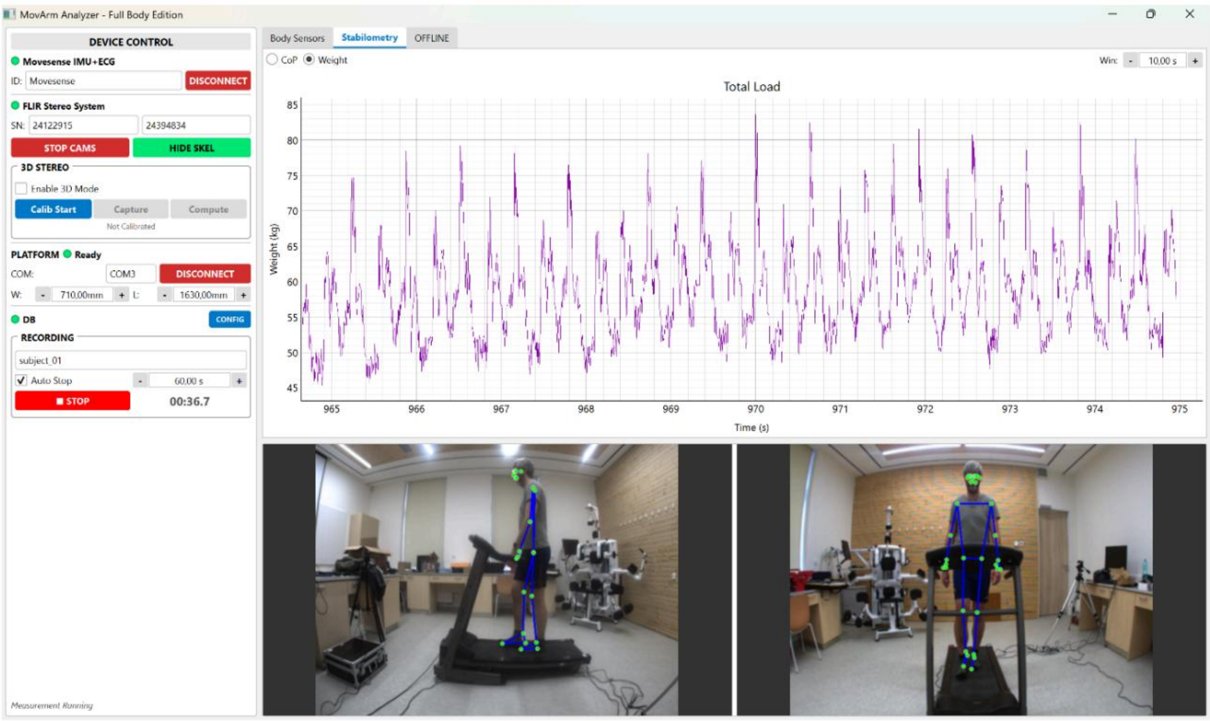

Fig. 16: Total Load graph. The curve shows the change in measured weight over time, which corresponds to the phases of the stride cycle (loading and unloading) when walking on a treadmill.

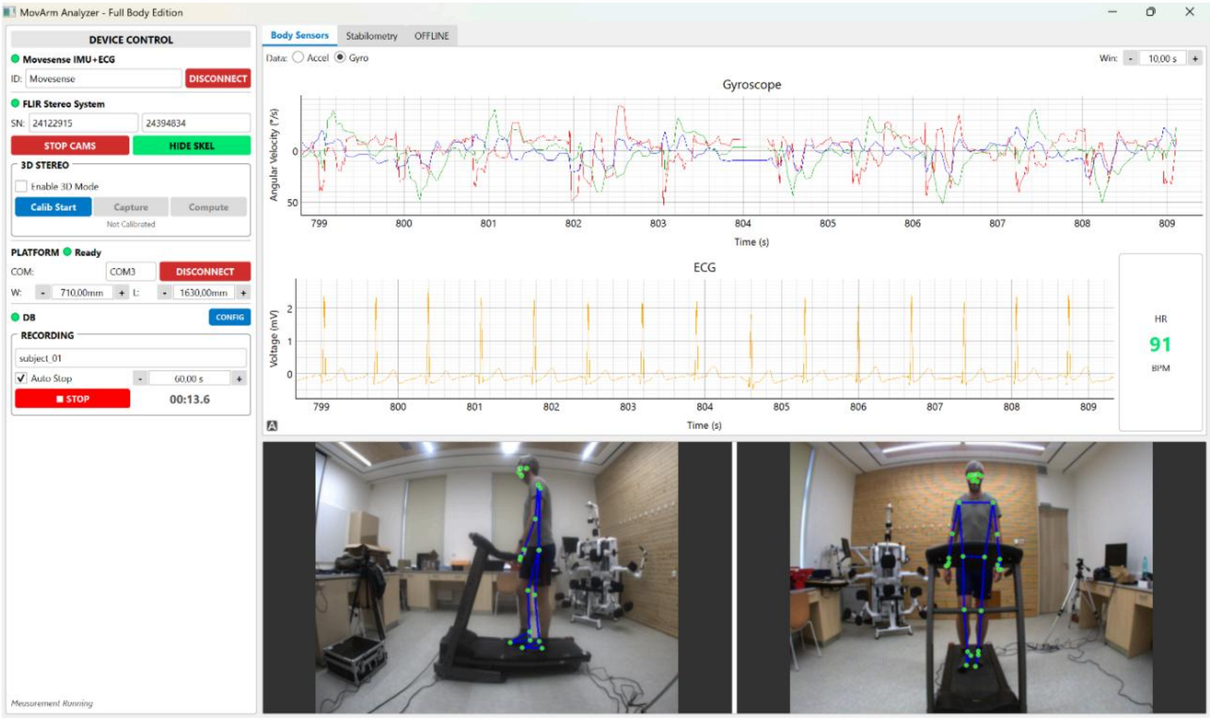

Fig. 17: Gyroscope data display. The top graph now shows angular velocity, while the bottom graph monitors ECG and heart rate.

6. User interface and data visualization (offline)

The offline mode of the application represents an analytical superstructure above the data layer. Unlike real-time visualization, it allows you to work retrospectively with already saved sessions and perform basic inspection and evaluation of measured quantities. The fundamental principle is that the offline mode loads data directly from the InfluxDB database and works with the same set of time series, which is available for export and external analysis. The session is defined by the session_id identifier, which ensures consistency across modalities and reproducibility of results during repeated processing.

6.1 Offline Stabilometry (CoP Path)

The stabilometric part of the offline mode displays the trajectory of the center of pressure (CoP Path) and allows for retrospective assessment of the dispersion and nature of postural stability during the session. In the context of the software solution, this view serves not only as an analytical output, but also as a control layer for the consistency of the recording (e.g. the presence of expected dynamics and the absence of unrealistic jumps).

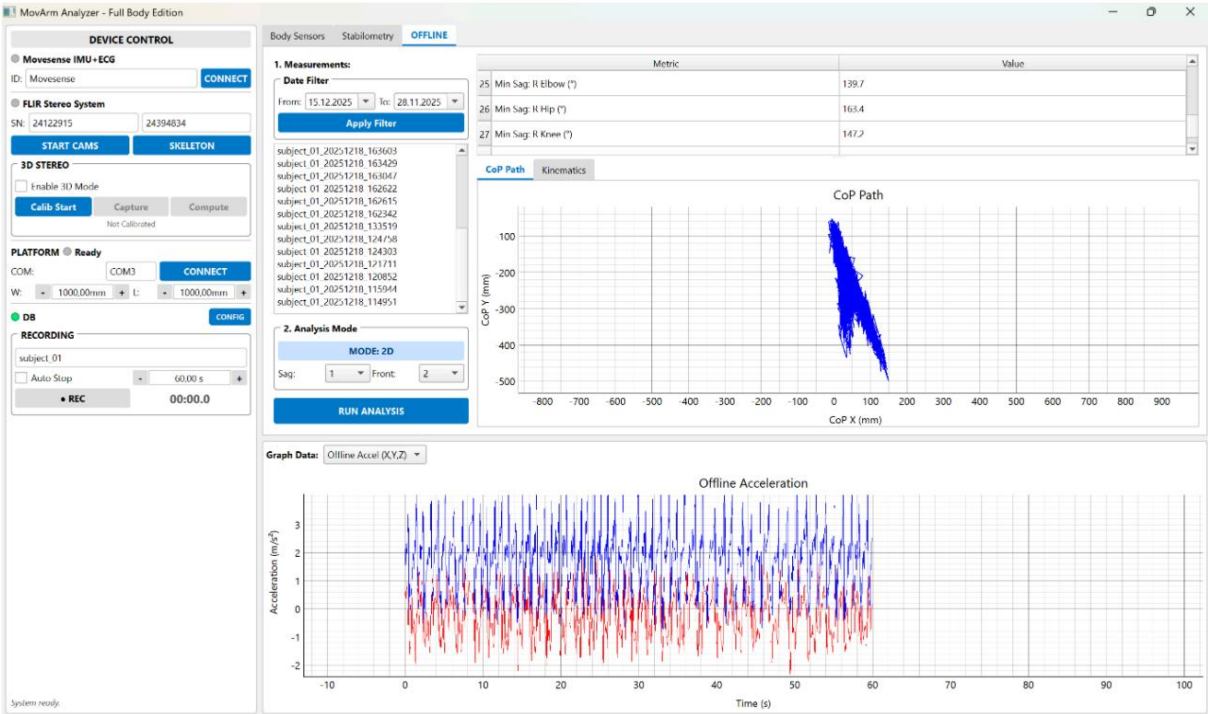

Fig. 18: Offline analysis of Stabilometry. On the left is a list of measured subjects. The graph in the middle (CoP Path) shows the dispersion of the measured subject's center of gravity during the test.

6.2 Offline kinematics and ECG

The kinematic part of the offline mode displays the courses of derived kinematic quantities and supplements them with a detailed ECG record. This combination allows interpreting changes in movement characteristics over time simultaneously with the physiological response within one session session_id. From the processing point of view, it is significant that the kinematic branch is derived from the stored time series of anatomical points and its quality is directly linked to the quality of their estimation and (in the case of 3D mode) to the quality of calibration and triangulation.

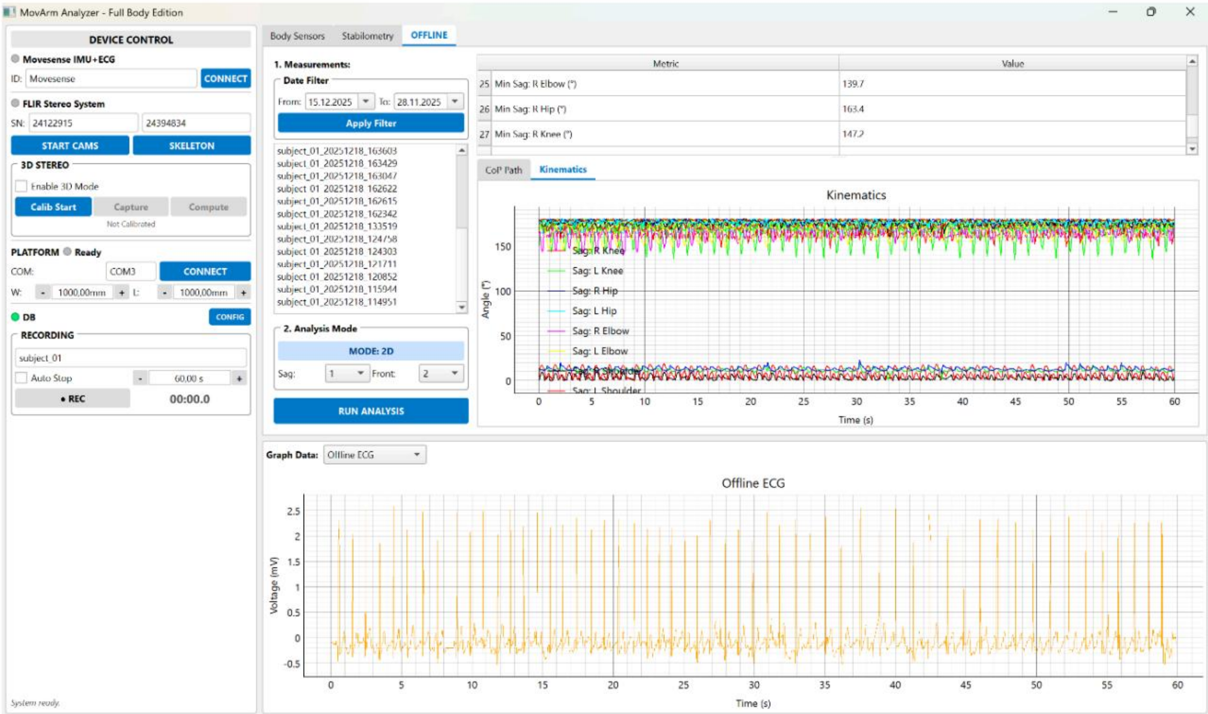

Fig. 19: Offline analysis of Kinematics and ECG. The upper graph shows the course of the angles in the joints (colored curves), the lower graph shows the detailed ECG recording

7. Benefits and applications of the software

The main benefit of the application is the unification of the entire data chain into a single platform: from real-time collection through auditable storage to export and offline inspection. As an integration layer, InfluxDB brings reproducibility and session consistency based on session_id, which is essential for subsequent evaluation and for the creation of validated datasets.

The MainWindow + Workers architecture allows you to extend the integration of additional data streams without fundamentally changing the core of the application, while maintaining GUI stability during concurrent collection.
Offline mode provides immediate feedback on session quality and enables basic evaluation without having to leave the application environment, while export to CSV creates a standard interface for subsequent analysis in external tools.