

Stepping into the Future:

Smart Footwear, Robotic Tracking, and AI for Next-Generation Rehabilitation

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Rehabilitation is often described as a journey—one marked by persistence, gradual progress, and deeply personal milestones. Yet despite its importance, the way we measure recovery has long remained limited, relying on brief clinical observations and specialized laboratory assessments that capture only fragments of a patient's progress.

Today, researchers at Qatar University are reshaping this landscape. By combining wearable technology, robotics, and artificial intelligence, they are creating a new paradigm-one where every step a patient takes can be measured, understood, and improved in real time.

At the heart of this transformation are two pioneering innovations: SHIBBY and MESHY. Together, they form an integrated, intelligent system that captures human movement from both within the body and across the surrounding environment-offering an unprecedented, holistic view of gait and rehabilitation.

Reimagining Rehabilitation: From Snapshots to Continuous Insight

Traditional rehabilitation assessment methods are often episodic. Patients visit clinics periodically, where clinicians evaluate their progress using visual observation or specialized equipment. While effective to a degree, these methods provide only isolated snapshots of recovery, missing the continuous and dynamic nature of human movement.

The vision behind SHIBBY and MESHY is fundamentally different. It shifts rehabilitation from a series of disconnected assessments to a continuous, data-driven journey, where progress is monitored in real time, and insights are always within reach.

This transformation is not merely technological—it is conceptual. It redefines rehabilitation as an ongoing, intelligent process that adapts to each patient's unique needs.

SHIBBY: Intelligence Embedded in Every Step

At the core of the wearable system is SHIBBY, a compact multi-sensor smart insole designed to fit seamlessly within customized footwear. Though small, it represents a significant leap in rehabilitation technology (Figure 1).

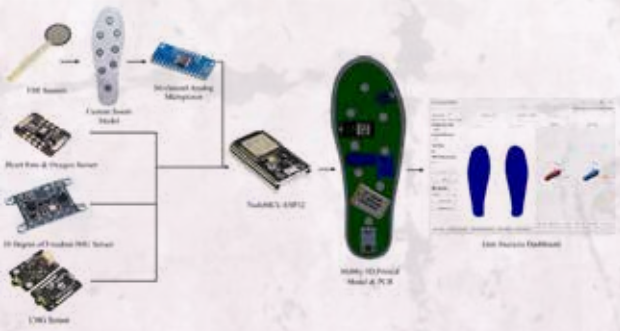


Figure 1: The SHIBBY smart insole.

Embedded within SHIBBY is an array of force-sensitive sensors that continuously map how the foot interacts with the ground. With each step, the system captures detailed information about plantar pressure distribution, revealing how weight is transferred, how balance is maintained, and how symmetry evolves (Figure 2).

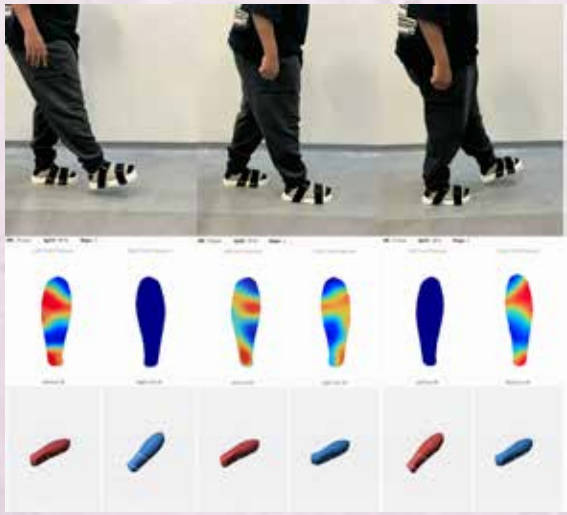


Figure 2: Foot pressure distribution captured by SHIBBY.

These measurements are critical in rehabilitation, particularly for patients recovering from conditions such as stroke, injury, or mobility impairments.

But SHIBBY goes further.

It integrates multiple sensing modalities, including:

- Inertial motion tracking to capture movement dynamics
- Heart rate monitoring to assess physiological response
- Electromyographic signals to measure muscle activation

Together, these data streams provide a rich, multidimensional picture of human movement-linking biomechanics with physiological function (Figure 3).

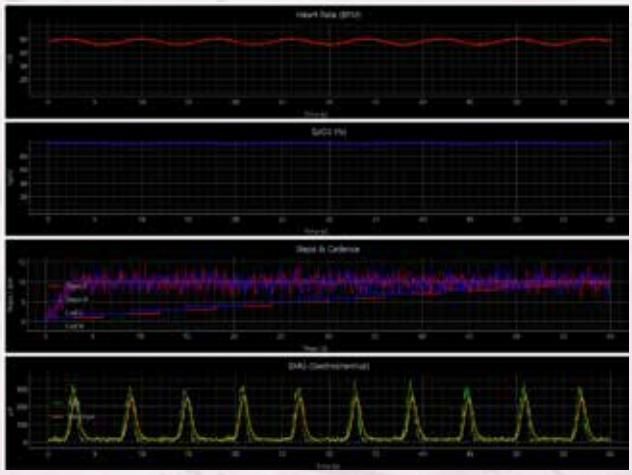


Figure 3: Integrated data streams linking biomechanics and physiological function.

All data is transmitted wirelessly to an interactive digital dashboard, where clinicians can visualize:

- Step patterns and cadence
- Load distribution and balance
- Muscle activity and cardiovascular response

What was once complex and difficult to interpret is now presented as clear, actionable insights. This empowers clinicians to make more informed decisions and enables continuous monitoring beyond the confines of traditional laboratory settings.

MESHY: Seeing Movement in Space

While SHIBBY captures what happens within the body, MESHY provides an equally powerful external perspective.

MESHY is an autonomous, LiDAR-based robotic platform designed to follow patients as they walk naturally. Using advanced laser scanning technology, it continuously tracks position and movement with remarkable spatial accuracy (Figure 4).

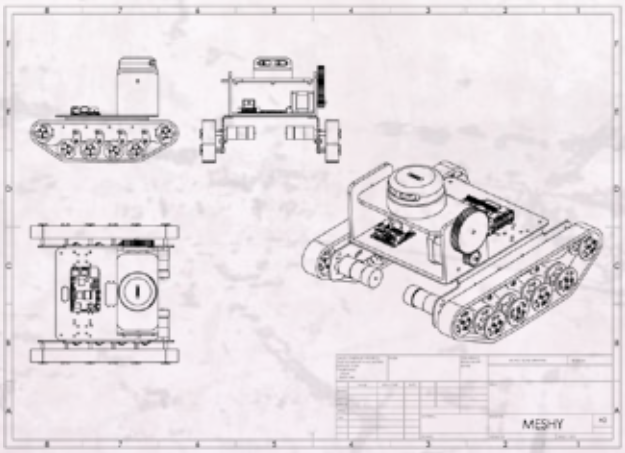


Figure 4: MESHY robotic system for patient movement tracking.

As patients move, MESHY reconstructs their walking trajectory in real time (Figure 5), generating key performance metrics such as:

- Total walking distance
- Path consistency
- Lateral drift
- Overall movement stability

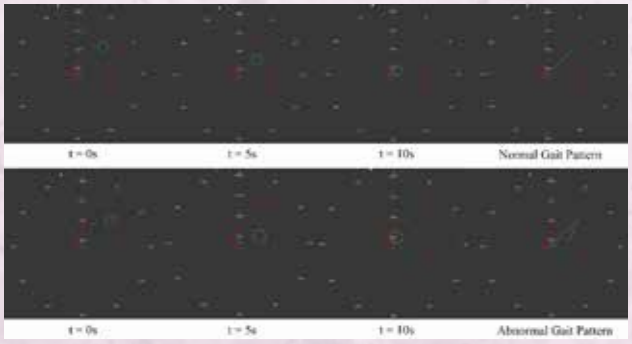


Figure 5: MESHY real-time gait trajectory tracking.

Yet its capabilities extend far beyond simple tracking. Through a rotating LiDAR system, MESHY creates a dynamic three-dimensional representation of the patient in motion (Figure 6). This enables detailed analysis of complex gait characteristics, including:

- Postural alignment
- Trunk sway
- Stride variability
- Limb coordination

These are subtle yet critical indicators of recovery—often difficult to quantify using conventional tools. By capturing them with precision, MESHY provides a deeper, more nuanced understanding of how patients move and improve over time.

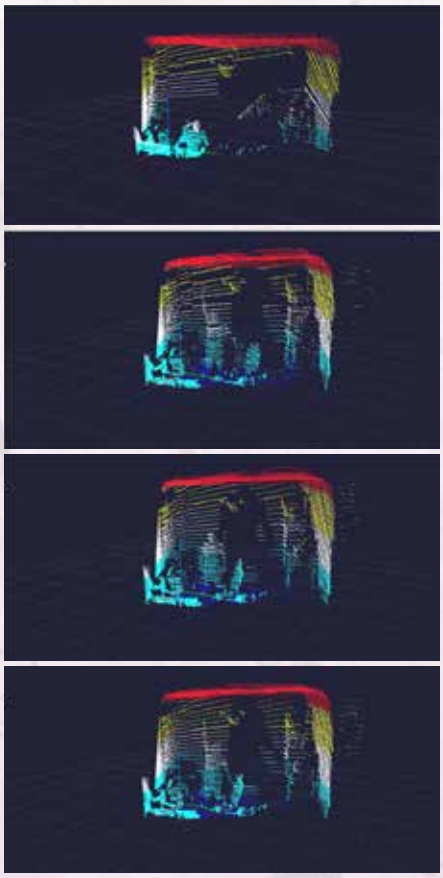


Figure 6: 3D patient motion model created by MESHY.

A Unified Vision: Where Data Meets Understanding

Individually, SHIBBY and MESHY are powerful tools. Together, they create something far greater: a unified system that bridges the internal and external perspectives of human movement.

By synchronizing wearable sensor data with spatial trajectory mapping, the system delivers a dual-perspective model of gait. It connects what is happening inside the body—muscle activation, pressure distribution, physiological response—with what is observed externally—movement patterns, posture, and spatial stability.

This integration marks a significant step forward in rehabilitation science. It allows clinicians to move beyond isolated measurements and toward a holistic, data-driven understanding of recovery.

In this model, every step is no longer just recorded—it is interpreted, analyzed, and transformed into meaningful insight.

Accessible Innovation: From Clinics to Homes

A key strength of the SHIBBY–MESHY system lies in its accessibility. Unlike traditional laboratory-based systems, which are often expensive and location-bound, this integrated solution is designed to be:

- Portable
- Cost-effective
- Scalable

This makes it suitable not only for clinical environments, but also for supervised home use. Patients can be monitored more frequently and consistently, without the need for constant hospital visits.

Such accessibility opens the door to personalized rehabilitation pathways, where treatment plans evolve based on real, continuous data rather than occasional assessments.

Shaping the Future of Healthcare

As healthcare systems worldwide move toward digital transformation, innovations like SHIBBY and MESHY highlight what the future can look like: intelligent, connected, and centered on the patient.

This work also reflects the strength of interdisciplinary collaboration. By bringing together expertise in engineering, medicine, and applied sciences, the research team has created a solution that is both technologically advanced and clinically meaningful.

The involvement of students further underscores the importance of education in driving innovation. Through hands-on participation, the next generation of engineers and researchers is gaining the skills needed to tackle complex healthcare challenges.

Conclusion: Every Step, Measured and Understood

Rehabilitation is no longer confined to clinics or defined by occasional assessments. With SHIBBY and MESHY, it becomes a continuous, intelligent process—one that captures the full complexity of human movement.

In this new paradigm, data is not just collected; it is translated into understanding. Progress is not just observed—it is quantified and guided.

And most importantly, every step a patient takes becomes part of a larger story of recovery—one that can be measured, supported, and ultimately transformed.

In this future, every step is not only taken—but truly understood.