INNOVATION PARTNERSHIPS
UNIVERSITY OF MICHIGAN

Joint Sensor to Measure Degrees of Freedom

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Category
Medical Devices
Life Sciences
Accelerate Blue Foundry - 2025/Life Sciences

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Accelerate Blue Foundry - 2025 (Life Sciences)

OVERVIEW

A low-cost, wearable patch inspired by kirigami (the art of paper cutting) enables precise, real-time measurement of human joint motion by conforming to complex body curves and capturing dynamic data—positioning itself to reinvent rehabilitation, sports training, and musculoskeletal health monitoring.

DESCRIPTION

This technology integrates thin, laser-cut plastic sheets with intricate patterns inspired by kirigami, allowing the flat material to transform into 3D shapes that wrap smoothly around body joints like the shoulder. Unlike today's motion sensors, which are bulky, rigid, or only measure simple flexion and extension, the kirigami patch moves and flexes naturally with the user, enabling it to track motion across multiple axes without wrinkling or distorting. Strain sensors, placed at key locations on the patch, detect subtle deformations as the joint moves, converting these into digital signals that quantify joint angles and movements. Importantly, the flat manufacturing process leverages existing, scalable techniques—reducing costs and simplifying mass production—while the device provides far more actionable data than the manual tools (like physical therapy protractors) currently in use. Additional sensing modalities that can be monolithically incorporated relatively easily include: temperature, heart rate, skin electrical conductivity, sound, etc. Additional / future applications may include remote control of robots, control of assistive robotics / prosthetics, haptic feedback, and others.

Published work on this and related kirigami-enabled device technology includes:

- "Developable Rotationally Symmetric Kirigami-Based Structures as Sensor Platforms"
- "Multifunctional composite kirigami skins for aerodynamic control"
- "Identifying internal and external shoulder rotation using a kirigami-based shoulder patch"
- "A Kirigami-inspired Shoulder Patch to Identify Shoulder Humeral Rotation"

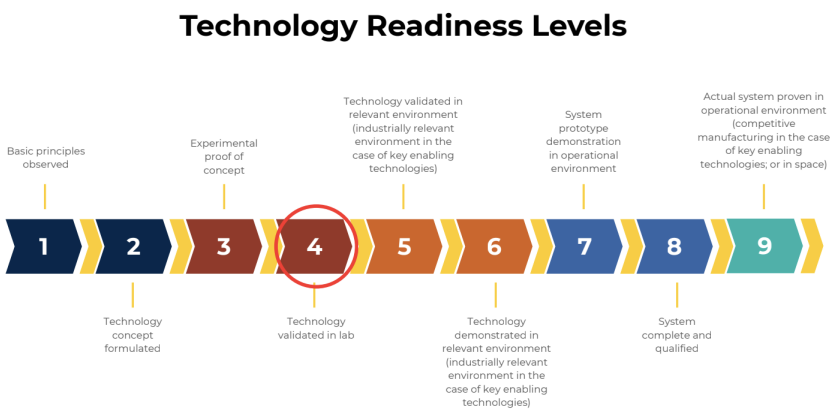
News coverage:

- https://news.umich.edu/kirigami-sensor-patch-for-shoulders-could-improve-injury-recovery-athletic-training/
- https://www.popularmechanics.com/technology/design/a29489461/kirigami-sensor-patches/
- https://physicsworld.com/a/low-cost-kirigami-sensor-tracks-shoulder-movement/
- https://www.advancedsciencenews.com/a-kirigami-based-sensor-when-art-and-technology-stand-shoulder-to-shoulder/

VALUE PROPOSITION

- **Conforms to Any Joint:** The kirigami structure allows the patch to seamlessly wrap around complex, curved joints (such as the shoulder) that traditional wearables cannot measure accurately.
- **Low-Cost, Scalable Production:** Manufacturable flat using standard laser-cutting, making it inexpensive (projected < $10/unit) and suitable for widespread distribution, even for at-home patient use.
- **Accurate, Real-Time Data:** Continuously and quantitatively captures multi-axis joint movement, outperforming both manual measurements and most existing digital wearables; this enables remote monitoring, better adherence, and athlete feedback.
- **Extendable platform**: Configurable for multiple sensing modalities and indications.

TECHNOLOGY READINESS LEVEL



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INTELLECTUAL PROPERTY STATUS

Issued Patent:

- US12152910

Other Patent Application is Pending.

MARKET OPPORTUNITY

TThere is a pressing need in rehabilitation, sports medicine, and remote health monitoring for affordable tools that can track the full range of joint motion continuously and accurately—applications include injury / surgery recovery, athletic training, physical therapy adherence, ergonomics, and even integration into augmented reality for fitness or workplace safety. For example, over 120 million Americans live with musculoskeletal disorders, while physical therapy market opportunities exceed $45 billion/year in the U.S., and wearable health tech adoption is growing rapidly. The kirigami sensor patch aligns with trends toward telehealth, data-driven fitness, and remote patient engagement.

Recent years have seen explosive growth in the global wearable sensor market (CAGR >20%), but few solutions address joint motion monitoring with both clinical accuracy and consumer scalability—underscoring this technology's disruptive potential.