

міжнародної наукової конференції (Київ, 1–2 березня 2024 р.) [Електронний ресурс]. Київ : УкрІНТЕІ, 2024. С. 17–20.

5. Чернова Т., Пращур О. XIV Міжнародна науково-практична конференція «Технологічна освіта: сучасні реалії та перспективи розвитку», присвячена пам'яті академіка Дмитра Тхоржевського. Київ, 2025. 389 с.

6. Гордієнко Т. В. Особливості інтеграції мистецтва і трудового навчання в початковій школі. НАУКОВІ ЗАПИСКИ НДУ ім. ГОГОЛЯ. Психолого-педагогічні науки. 2025. №1 с.55-63.

7. Arts-based learning in primary schools: connecting dance and visual arts <https://schooleducation.ec.europa.eu/sr/discover/viewpoints/arts-based-learning-primary-schoolsconnecting-dance-and-visual-arts> (Дата звернення 24.01.2025).

8. Івашина Л. Л., Бишовець Л. Г., Оліферчук О. Г. Крафтові сири як перспективний екопродукт для закладів ресторанного господарства. *Інновації та технології в сфері послуг і харчування*. 2023. № 2 (8). С. 32–39.

DOI <https://doi.org/10.36059/978-966-397-630-3-52>

TYOLOGICAL STUDY OF WIRING LINE POSITIONS AND STRUCTURAL DESIGN IN SMART PANTS

Liu Yi

*PhD student at the Department of Fashion and Style
Kyiv National University of Technologies and Design Kyiv, Ukraine*

Rubanka A.

*PhD in Engineering,
Associate Professor at the Department of Fashion and Style,
Kyiv National University of Technologies and Design
Kyiv, Ukraine*

Electronics can be incorporated into textiles through attachment, integration during weaving, or yarn-level embedding, enabling garments to function as a key carrier of wearable devices. Smart pants are prone to deformation and relative slip during walking and flexion–extension, which can shift routing paths and sensor lead placement and undermine measurement reliability. A typological description of wiring-line placement that accounts for lower-limb motion is therefore required.

Using five smart pants as case samples, this study establishes longitudinal wiring-line types and criteria based on the placement of

conductive-textile boundaries, interconnects, and sensor leads, covering the spiral shaping longitudinal line and the channel-based longitudinal line. It compares turning trajectories, the number of turning points, and risks of cumulative mechanical loading across line types, and proposes structural constraints and design guidelines for cross-joint routing to reduce measurement errors induced by slippage.

This study adopts a case-based sample analysis. Based on the structural line placement and wiring organization of five smart pants, it summarizes the routing patterns of conductive-textile boundaries, interconnects, and sensor leads, and derives two wiring types – the spiral shaping longitudinal line and the channel-based longitudinal line – together with their corresponding motion-adaptation mechanisms.

The spiral shaping longitudinal line refers to a longitudinal dominant line in which the circumferential position of a seam or panel boundary changes continuously as it extends along the long axis of the lower limb. The line typically starts from the lateral hip or the lateral waist-hip region, runs downward along the lateral thigh, gradually shifts toward the anterior or posterior side of the leg, and then moves to the medial side or returns to the lateral side. This line type addresses circumferential slippage induced by the combined effects of walking and flexion-extension. By distributing turning surfaces along a longitudinal path, it transfers seam loads stepwise around the circumference and avoids repetitive stretching concentrated at a single circumferential location. Among the five smart pants samples, Nadi X (Figure 1) shows the clearest turning pattern, presenting a continuous turning trajectory in both front and back views and serving as a representative case [1]. Its line transitions from the lateral hip to the anterior and posterior thigh and then back to the medial side, so the anterior stretching and posterior compression generated during knee flexion-extension are not borne by one seam over time, reducing local accumulation near the seam. When conductive-textile boundaries, interconnects, or sensor leads follow this line, fewer turning points are required, pull at hardware edges and interfaces is less likely to accumulate, excessive local stretching near the seam is less likely to occur, and a more repeatable placement basis is provided for cross-joint sensing and feedback modules.



Fig. 1. The structural lines and style diagrams of Nadi X

The channel-based longitudinal line is typically defined by one or two symmetric straight longitudinal seams. It is most often positioned on the lateral or slightly outer side of the leg and appears as a continuous band-shaped panel zone in both front and back views. A typical placement runs from the lateral hip to the lateral thigh and extends downward along the lateral thigh. Structurally, this band functions as an organizational strip for the electronic system. It centralizes component fixation and conductive routing so that electrode contact regions or sensing surfaces on the buttocks and the anterior and posterior thigh undergo smaller relative displacement during flexion–extension. At the same time, connection points, reinforcement segments, and transition segments are constrained to locations with fewer folds during flexion–extension, reducing conductive-route fatigue and contact fluctuations. Lateral placement also shifts connectors and local thickened sections away from the crotch and inner-thigh friction zone, enabling more direct positioning after donning and doffing and lowering the risk of pull caused by repeated adjustments.



Fig. 2. Eaglefit EMS, Wisenfit EMS and Athos's structural lines and style diagrams

Across the samples, channel-based longitudinal lines exhibit a length hierarchy. The lateral lines of Eaglefit EMS (Figure 2a) and Wisenfit EMS (Figure 2b) correspond to long-segment organizations [2, 3]. Their line placement extends from the lateral hip down to the calf and in some cases approaches the ankle, forming a continuous longitudinal band that facilitates routing along the line and distribution to multiple zoned electrodes. In Eaglefit EMS, the control unit is fixed at the lateral hip or the lateral upper thigh, and wires are distributed from this location to electrode regions, so the channel serves as both a fixation site and a routing strip. Wisenfit EMS adopts a similar long channel to support centralized management of

electrodes and cables. By contrast, the lateral line in Athos (Figure 2c) is closer to a short-segment organization [4, p. 210]. The placement concentrates around the upper crotch to the upper thigh without forming an equally long downward channel. Its core module is mounted on the outer thigh, and the structure prioritizes module positioning and signal aggregation near the hip, while the planar electrode regions are distributed around the anterior and posterior thigh and the buttocks, so the longitudinal band mainly provides local positioning and fixed boundaries.

This paper examines conductive-textile boundaries, interconnects, and sensor leads in smart pants and identifies two longitudinal line-position types. The spiral shaping longitudinal line follows the lower-limb axis while shifting around the leg circumference. This configuration distributes seam loading across different circumferential regions, reduces repeated local stretching, and limits pull at hardware interfaces, as shown by Nadi X. The channel-based longitudinal line uses a straight lateral or slightly outer-leg seam band to organize module fixation, reinforcement, and routing. It reduces displacement and cable fatigue during flexion–extension and keeps connection points away from the crotch and inner-thigh friction zone. Eaglefit EMS and Wisenfit EMS represent long continuous lateral channels, while Athos represents a short hip-proximal channel for local module aggregation.

References:

1. Wearable X. Posture monitoring and vibrational guidance. URL: <https://www.wearablex.com/pages/how-it-works>.
2. Eaglefit EMS. Professionelle EMS-Technologie – für Zuhause und Studio. URL: <https://www.eaglefit.de/en>.
3. Wisenfit EMS. Wisenfit: New Generation Phone-Powered Electrical Sportswear. URL: <https://www.kickstarter.com/projects/1327913971/the-portable-phone-powered-electrical-sportswear>
4. Lynn, S. K., Watkins, C. M., Wong, M. A., Balfany, K., & Feeney, D. F. (2018). Validity and Reliability of Surface Electromyography Measurements from a Wearable Athlete Performance System. *Journal of sports science & medicine*, 17(2), 205–215.