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Fab-Tune: A regulator of the Basic Features of Cell Phone

Md. Mostafizur Rahman[1, 2], Md. Abdus Shahid[2], Protik Barua[3], Rajib Hasan[3], Badhon Baria[1], Mohammad Bellal Hoque[1], Md. Mizanur Rahman[3]*

[1]Department of Textile Engineering, World University of Bangladesh, Uttara, Dhaka, Bangladesh
[2]Department of Textile Engineering, Dhaka University of Engineering and Technology, Gazipur 1707, Bangladesh
[3]Department of Mechatronics Engineering, World University of Bangladesh, Uttara, Dhaka, Bangladesh

ABSTRACT
The rise of advanced engineered fibers and sophisticated electronics has paved the way for a new category of textile materials that integrate technology. Smart or electronic textiles are characterized as fabrics that engage with their environment. Smart textiles are fabrics that can respond and adjust to environmental stimuli. The origin of the stimulus and reaction may derive from electrical, thermal, chemical, or magnetic sources. In recent years, smart textiles have been developed to merge electronics with textiles. A smart textile typically possesses five primary functions: sensors, actuators, data processing, energy supply, and communication. The advancement of thin, flexible, and highly sensitive sensors positions smart textiles as the future of fashion. This study outlines an endeavor to create a smart apparel system in Bangladesh, termed “Fab-Tune,” designed to regulate the basic features of mobile devices and music players via Bluetooth. The embedded system comprised a microcontroller, capacitive touch sensors, a battery, a battery management system, and a voltage regulator. Fab-Tune proficiently executed orders to initiate a playlist, play, and pause. Modify the volume, access the preceding track, and progress to the subsequent track on a playlist without tactile engagement with the mobile device. The Fab-Tune can remotely silence a mobile device. The technology will be integrated into the sleeve or other appropriate locations of apparel for mobile operation. The created system demonstrates a decent responsiveness during usage. This is the inaugural endeavor in Bangladesh, and development is essential for its advancements and commercialization.

Keywords: Fab-Tune, Smart Textiles, Mobile, Music player, Embedded system.

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1. Introduction

In the dynamic realm of textiles, where conventional fibers and materials have prevailed in the apparel business for millennia, the advancement of smart wearable electronic textiles is now facilitating the emergence of interactive and intelligent garments [1]. While traditional textiles remain significant, there is a substantial increase in ingeniously designed structures that can perceive their surroundings, alter their form, and execute certain functions. Smart materials are defined as substances that utilize principles from conventional sources, however are tailored through their morphological, physical, and chemical structures to deliver certain performance characteristics. There is an increasing desire for fabrics that not only safeguard the body but also respond to various scenarios.

The amalgamation of fashion and technology can be traced back to the 1600s when metallic threads were incorporated into garments for their luster. While contemporary textiles predominantly utilize silver or nickel threads, the application of intriguing metallic yarns has existed for centuries. According to Hughes-Riley, functional textiles integrated with electronic components are currently regarded as the most prevalent materials of this type [2]. By integrating textiles with technology, they create materials that are adaptable, conformable, and interactive for future applications. The use of smart textiles is seen in the advancement of three study domains.

a) Conductive materials,
b) Miniaturized electronics (integration of electronics into textiles and objects), and
c) Wearable technologies utilizing wireless communication (facilitating interaction between individuals and gadgets) [3].

A sophisticated "wearable" textile system is designed to detect the human body and its surroundings by integrating various sensors. Notably, smart textiles capable of sensing and responding to the human body or external environment can function independently of electronic input, akin to the transformation of pinecones [3].

Smart textiles characterized by their evolving shapes, colors, and textures, have emerged as adaptable mediums for integrated electronics designed for various uses. Meyer et al. elucidated how smart materials alter in response to stimuli, yielding consistent and repeatable reactions and outputs [4]. In photochromic materials, the connection exists between the input 'light' and the output 'color'. Moreover, piezoelectric materials exhibit mechanical deformation in response to an electric charge or voltage fluctuation, and conversely [4]. Fig. 1 depicts a basic feature of smart textiles.

Additional instances are elucidated throughout this edition of Textile Progress. Traditional textiles, while functional, generally do not sense, react, or adapt to external stimuli, with the exception of moisture absorption and release by protein and cellulose fibers in response to variations in ambient humidity. The fundamental criterion for a smart textile is its capacity to detect environmental conditions or external stimuli, categorizing it as 'passive

*Corresponding Author Email Address: rahman6@textiles.wub.edu.bd

smart.' If the material can react upon sensing, it is classified as 'active smart'; further categories are detailed in Table 1. Responses to stimuli can manifest as mechanical, thermal, electrical, magnetic, and other forms. The material's characteristics alter in response to environmental changes. The primary differentiating characteristics of smart fabrics are their "soft" composition, flexibility, and drapability [5]. The alteration in reaction to external stimuli is contingent upon the substance itself.

Mainstream textiles are currently combining digital technology and sophisticated fiber creation to innovate apparel for the future. Wright & Keith define 'wearable technology' or 'wearable devices' as electronics and computers embedded in clothing, designed for comfortable wear on the body [7]. Wearable technology synthesizes textiles and gadgets that interact or execute functional tasks in response to actions and commands. Philip and Levi Strauss created the inaugural smart wearable jacket featuring an integrated mobile phone and MP3 player [8]. A wearable device integrated into clothes that contains intelligence (sensors and electronics) can sense, communicate, navigate, and activate other devices. Global research and development teams are currently creating wearable technology to improve quality of life, such as sports performance apparel that incorporates embedded technology to deliver immediate physiological data to users, or for healthcare professionals to track vital health indicators of patients in critical care. Consequently, the integration of electronics may catalyze the swift transformation of the textiles and apparel business. Wearable technology, or electronic devices integrated into materials, such as sensors and analytical algorithms, can monitor, analyze, and influence the behavior of the user [9]. Large, cumbersome embedded electronics are now being supplanted with discrete circuits that can be integrated into the material's structure to enhance perceived comfort.

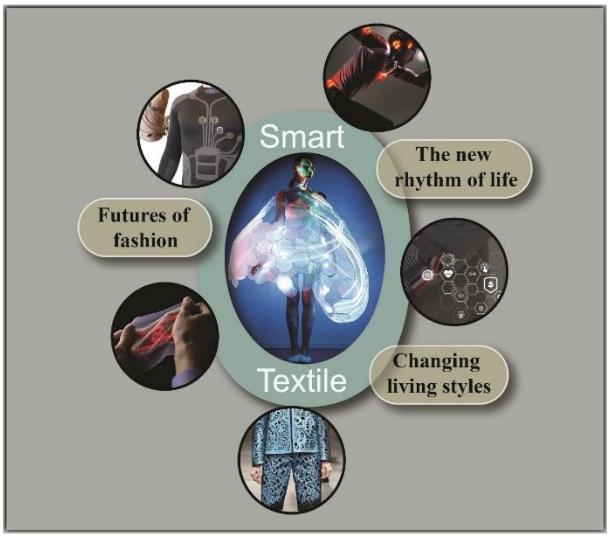

Fig.1 A feature of smart textiles.

Embedded systems are information processing systems integrated into surrounding items, such as automobiles, telecommunications devices, textile fabrics or manufacturing equipment. Such systems possess numerous shared properties, including real-time limitations, dependability, and efficiency requirements. Embedded system technology is crucial for delivering ubiquitous information, a primary objective of contemporary information technology (IT). In light of the success of IT in office and workflow applications, embedded systems are anticipated to emerge as the most significant application domain of information technology in the forthcoming years [10].

Most embedded systems do not utilize keyboards, mice, or huge computer displays for their user interface. Instead, there exists a specialized user interface comprising push buttons, steering wheels, pedals, and other components. The user scarcely acknowledges the involvement of information processing. This has led to the emergence of a new era in computing marked by the vanishing computer. Numerous embedded systems are hybrid systems, incorporating both analog and digital components. Analog components utilize continuous signal values throughout continuous time, while digital components employ discrete signal values at discrete time intervals [11].

Table 1 Categories of smart textiles [5, 6]

Category	Definition
Passive smart textiles	Textiles capable of sensing environmental variables and stimuli exclusively
Active smart textiles	These perceive and respond to circumstances and stimuli.
Very smart textiles	Perceive, respond, and adjust accordingly
Intelligent textiles	Intelligent textiles can respond or be actuated to execute a function in a pre-programmed manner.

Embedded systems are inadequately represented in education and public discourse. Embedded chips are not promoted in television and print advertisements. The embedded system is utilized in various critical sectors like automobile electronics, aerospace electronics, railway systems, telecommunications, medical devices, military applications, authentication systems, consumer electronics, manufacturing equipment, smart buildings, and robots.

This study demonstrates a practical implementation of an embedded system integrated into the simple woven fabric for mobile control via Bluetooth. The product created under this system is named "Fab-Tune." “Fab-Tune” is an initiative that utilizes locally sourced materials to create the sample. Smart textiles or electronic textiles constitute an emerging and attractive field in affluent countries, although it remains a novel notion in Bangladesh. Exploring smart textiles will allow Bangladesh to secure a greater market share in international trade.

2. Materials & Methodology

The Fab Tune project incorporated capacitive touch sensors into clothing, enabling users to execute functions such as pausing videos, modifying volume, and answering calls by designated touch movements. The system employs the ESP32 DOW DQ6 microprocessor for signal processing, a Battery Management System (BMS) for effective power control, and voltage regulation for consistent operation via capacitive touch sensor. The user interacted with mobile devices via Bluetooth communication. The embedded system mechanism was utilized to construct the Fab-Tune, illustrated in Fig. 2. All instruments enumerated above are positioned on the plain-woven fabric following the block diagram. The components used are listed below:

a) **ESP32 DOW DQ6 microcontroller**: The central processing unit of the system, tasked with interpreting touch inputs and interfacing with the mobile device using Bluetooth.
b) **Conductive Touch Pads:** This pad, integrated into the fabric to recognize touch gestures, serves as the primary input mechanism. They are connected to an ESP32 DOW DQ6 touch capacitive pin, allowing the system to detect finger touch through conductive pads.
c) **Battery and power management:** FabTune is powered by a rechargeable battery, safeguarded by a Battery Management System (BMS) to prevent overcharging, undercharging, and overheating. This ensures efficient power utilization, prolonged battery life, and reliable system performance.
d) **Voltage regulation:** Utilizes an LDO MIC5219-3.3YM5-TR to provide a stable 3.3V output, ensuring that the ESP32 DOW DQ6 microcontroller and additional electronic components receive a consistent voltage for optimal operation.
e) **Slide capacitive touch sensor:** Used to turn the system on and off.

The instruments were linked by slender copper wire and secured to the fabric through human stitching. The copper wire is covered by manual stitching. The design incorporates capacitive touch sensors strategically placed in the fabric, such as on the sleeves or cuffs, enabling users to connect seamlessly with their mobile devices. Diverse touch patterns, like tapping, sliding, or long pressing, were configured to execute functions such as pausing a video, modifying the volume, or answering calls. The microcontroller was programmed to recognize these motions and transmit the necessary commands to the mobile device via Bluetooth. The BMS manages the battery's charge to ensure dependable functioning, safeguarding against harm from excessive use or overcharging. The voltage regulator maintains stable voltage levels for reliable performance. A sliding capacitive touch sensor enabled users to activate or deactivate the mechanism, providing control over the garment's operation.

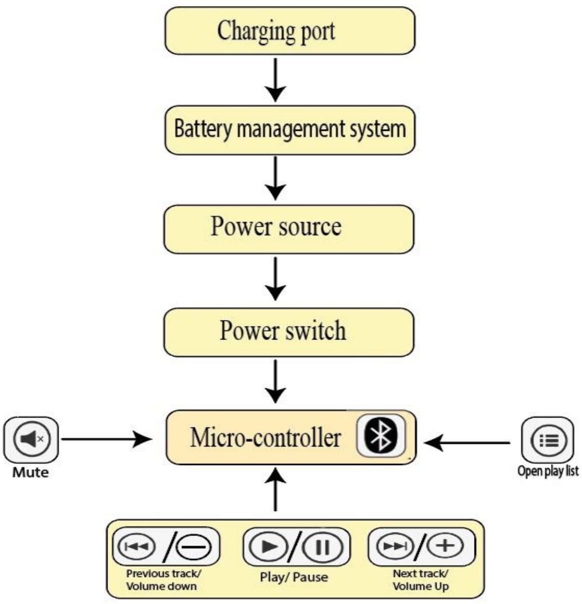

Fig.2 Embedded system block diagram of Fab-Tune.

The ESP32's integrated Bluetooth module facilitates wireless connection with the mobile device. Upon activation, the system transmits a Bluetooth pairing request to the user's mobile device. The functional block diagram is given below in Fig. 3 which illustrates the overall concept including components with proper connections. The implications of this project were based on this figure, where the push buttons are connected in series.

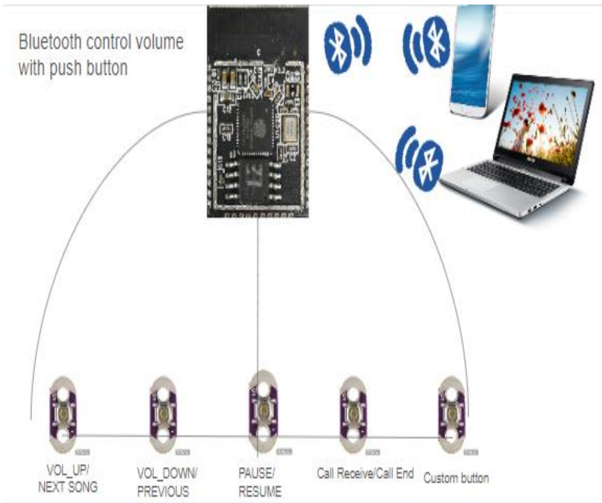

Fig.3 Functional block diagram

The microprocessor analyzes touch movements from capacitive sensors, translates them into precise commands, and broadcasts these commands over Bluetooth to operate the mobile device. The software is created utilizing the Arduino Integrated Development Environment. The touch sensors are calibrated for maximum sensitivity through the fabric, guaranteeing dependable detection of user inputs. The gesture recognition algorithm distinguishes distinct touch patterns and associates them with particular actions on the mobile device. Bluetooth integration facilitates effortless wireless connection between the apparel and the mobile device. Touch sensors, Bluetooth connectivity, and the power management system are all thoroughly checked to ensure they function properly. Each motion is tested to confirm it triggers the correct action on the mobile device, and battery life along with energy usage is reviewed to maintain optimal performance. The Fab Tune smart apparel system includes capacitive touch sensors, an ESP32 microprocessor, and Bluetooth technology, providing smooth hands-free mobile control. The project illustrates the convenience of smart clothing through the integration of mobile device control into ordinary apparel. The ultimate embedded design is illustrated in Fig. 4.

This picture illustrated the Fab Tune project, which integrated capacitive touch sensors into the fabric to manage mobile features such as music playback and volume control. The embroidered design had several sensors linked to an ESP32 microprocessor, enabling users to engage with their mobile devices via touch motions on the fabric. The artistic depiction harmonizes the circuit's functionality with an aesthetically pleasing design.

3. Results and Discussion

The developed Fab-Tune, utilizing an embedded system method, demonstrates a substantial capability to control mobile devices over Bluetooth. Fab-Tune effectively executed commands to initiate a playlist, play, and pause.

Adjust the volume, navigate to the previous track, and advance to the next track of a playlist without physically interacting with the mobile device. The Fab-Tune can mute a mobile device remotely.

The Fab-Tune can significantly impact our daily activities. An unexpectedly loud smartphone ringtone during an official meeting or in the prayer room might disrupt the entire atmosphere. The Fab-Tune has the potential to mitigate these issues. A music enthusiast can experience uninterrupted enjoyment of their music without interacting with their mobile device during daily tasks.

The endeavor represents the initial prototype, and the creation of a planar circuit board (PCB), along with a performance assessment, will substantiate the proposed model.

4. Conclusion

The Fab-Tune can profoundly influence our daily routines and enhance our lifestyle's intelligence. The creation of Fab-tune represents an initial venture. Additional research and effort are necessary to enhance its user-friendliness and economic viability. The performance test will also assess the acceptance of the generated sample.

While smart textiles or electronic textiles represent a burgeoning and appealing domain in wealthy nations, it remains a new concept in Bangladesh. This area necessitates concentrated effort, study, and labor for mobilization. Investigating smart textiles will enable Bangladesh to capture a larger market share in global trade.

Fig.4 The developed sample of Fab-Tune.

5. Recommendations

a) The design of a planar circuit board (PCB) is necessary to consolidate all utilized electronics into a single structure.

b) Performance tests and analysis are also required to reveal the efficiency of the developed PCB.

c) The production facility for PCBs is uncommon in Bangladesh. A seamless flow of PCB is necessary.

6. Acknowledgement

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