



A New Paradigm of Chef Attire: Smart IoT Chef Jacket in Restaurant Kitchen

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Abstract: This study aimed to propose a new concept of chef uniforms using IoT technology. These days, Big Data Analytics and IoT offer many practical applications to the hospitality and tourism industry that improve workplace performance, safety, and sanitation. This paper will design a complete set of "Smart Chef Uniforms" based on current IoT technology and simulate the efficiencies compared to the traditional chef uniforms. The findings indicate that "Smart Chef Uniforms" is a promising gear with many ongoing initiatives in food production and foodsafety.

Keywords: Chef uniform, AI, IoT, Chef jacket, Chef performance, Safety

1. Introduction

The traditional chef's outfit comprises a double-breasted jacket, checked pants, neckerchief, and a chef's hat (CIA, 2001; Robinson, 2013). The white chef jacket is acknowledged as a standard outfit, and most professional chefs still inherit the tradition of showing high regard for their careers. A clean impression to the clientele is another critical reason a traditional white chef uniform still stands as a symbol of personal hygiene (Cullen, 2005; Tomshinsky, 2014). However, surprisingly, this chef outfit (Figure 1) began in 1822 when French artist Marie-Antoine Careme released a sketch called "Le Maitre d'Hotel Francais (Goldstein, 1995)." Most kitchen staff still wear the same uniform from the last 1800s.

Only a handful of research has been conducted about chef uniforms in the literature. Consequently, there is a significant gap in the chef outfit improvement study. Some researchers investigated different types of design, comfort, fit, and protection (Perry and Lee, 2017; Ehnes, McQueen, and Strickfaden, 2012) or the desires and expectations of chefs wearing the uniforms in terms of productivity (Black, Freeman, and Rawlings, 2018; Zhang, McQueen, Batcheller, Paskaluk, and Murtaza, 2015). Remarkably, Ehnes et al. (2012) designed a focus group interview using culinary arts students and asked them about comfort, injuries, and protective chef uniforms in the kitchens. This study identified that longer sleeve chef jackets had a chance to cause problems with personal hygiene and job-related accidents. Also, Black et al. (2018) examined female chef jackets based on the Functional, Expressive, Aesthetic (FEA) Consumer Needs model. The research suggested a prototype of chef uniforms that improved the FEA in the kitchen by the female chef.

Despite these studies, the foodservice industry is still behind in improving chef uniforms. The industry is experiencing the fourth industrial revolution in emerging technologies. Other sectors are putting a lot of application into adopting artificial intelligence (AI), Big data analytics, Internet-of-Things (IoT), robotics, fifth-generation wireless technologies, and quantum computing (Schwab, 2016). These enormous waves will change how we live, work, and generate and distribute value. Commercial foodservice is where the researchers can apply a ton of recent technologies. The convergence of new technology and chef uniform will be ideal for refining productivity, safety, and sanitation.

This study aims to conceptualize a new example of chef uniforms using new technologies. The findings and prototype will benefit literature, and manufacturers will develop new chef uniforms that encounter chefs' expectations and needs.

2. Literature Review

2.1. The Functions of the Chef Uniform

The priority goal for chefs is to prepare delicious food and deliver it to customers in a timely manner. A professional kitchen, especially a larger kitchen with many staff, always has dangers because of the enormously chaotic working environment. The commercial kitchen's cooking station is often higher than 100 F due to the heat and humidity from the kitchen equipment, such as the oven, stove, flat-top, steamer, and dishwashing machine. (Simone and Olesen, 2013). For doing the tasks, kitchen staff could easily bump into another team, get too near to a hot flame, or open a pot lid too quickly and expose it to a burst of hot steam. Thus, Chef uniforms should be able to protect against burn injuries and a barrier from lacking thermal kitchen conditions that negatively affect the productivity and performance of kitchen staff. Chef uniforms can be made of various materials. The most widespread fabrics are cotton or polyester/cotton blends (Zhang et al., 2015). However, these materials can not protect against scald injuries and improve repellency from hot oil and liquid stains. Zhang et al. (2015) examined the minimal protective capability of commercial chef jackets against hot water, hot surface contact, and low-pressure steam burns. The results found that second-degree burn injuries occurred in less than two seconds with the commercial single-layer chef jackets. In another study on chemical protection, a typical chef's uniform fabric showed burns from the chemical within 5-10 seconds (Stull and McManus, 2004). Both research results disclosed that commercial chef uniforms have insufficient or marginal protection for thermal hazards in the kitchen environment.

Another essential value of chef uniforms is comfort in a bustling kitchen environment (Black et al., 2018). Since becoming the standard by French artist Marie-Antoine Careme in the 19th century (figure 1), the traditional chef outfit was long-sleeved snug jackets with double buttons down the front, loose pants, a chef's hat, neckerchief, and an apron (CIA, 2001; Robinson, 2013). Chef jackets are typically double-breasted to cover up spills and made of thick cotton or polyester. The advantage of the double-breasted design is the flap can be reversible to hide stains and offer enhanced protection from heat, steam, and splashes (Zhang et al., 2015). Long-sleeved jackets enable the chef to use the sleeve to protect their hands when reaching over the hot oven and an open flame. Long chef pants are classically baggy with an elastic waistband, designed to protect against hot liquids and steam hazards.



Figure 1: Initial Chef uniform sketch by Marie-Antoine Careme in the 19th century

2.2 Wearable Internet of Things for Emerging Chef Uniforms

The initial idea of wearable technology was introduced in the 1960s (Mann, 1997), and the effort to develop the wearable application was expedited after commercializing inexpensive compact and lighted mobile tools in the 2000s. The beginning of wearable technology research topics focused on simultaneously designing and enabling functions optimized for specific purposes while augmenting their fundamental roles. Currently, critical wearable technologies research

includes wearable sensing (IoT), wearable interfaces connected to Blockchain technology, and increasing functions of clothing (Lee and Lee, 2019; Majeed and Rupasinghe, 2017).

Especially, IoT can bring plenty of opportunities for chefs to increase their work efficiency and access data that allow chefs to organize their work orders in the bustling cooking environment. The recognition of a chef's efficiency is based on tracking routine and body movements such as prepping, cooking, moving ingredients, platings, and sending dishes to servers. It also includes recognizing changing from one motion to another, such as standing to sitting, standing to bend, and standing to walk. Generally, IoT can bring an abundance of opportunities for chefs' efficiency because IoT has access to data that can find metrics on chefs' performance (Mazzoldi et al., 2002). The relationship between activities and performance has been researched in different sectors, such as sports (Perry and Lee, 2017), health treatment (Park et al., 2017), safety (Wang et al., 2017), and education (Lee and Lee, 2019). Previous literature discusses the use of wearable IoT devices to improve the quality of activities for its tasks. The IoT typically receives a message to support taskers in understanding the performance quality or provide information on how to proceed. This information might be seen on the wearable screen, such as a smartphone or a smartwatch, or displayed on another screen. The wearer also gets notices or a signal of a message using audio or earpieces.

Wearable IoT sensing technology allows chefs to measure their vital signs, including body movement, temperature, stress level, and Safety (Dunne, 2010; Mazzoldi et al., 2002). IoT wearables use external detachable services fixed in garments, implanted in the body, or tattooed on the skin. These devices can provide a database to communicate the information used for decision-making. In this paper, external detachable and embedded-in garments IoT technology will be employed to fulfill the function and applicability of the chef uniform.

3. Research Methodology

Detachable IoT sensors are positioned and integrated into the wearable platform to deliver efficiencies and safety for kitchen activities that measure the chef's movements and analyze the activities. Previous studies in other sectors developed prototypes to offer different functions, including body temperature monitoring, moving patterns analysis, obstacle detection and warning for the visually impaired, and electronic temperature control for medical purposes (Park et al., 2017). These studies used simple methods to construct IoT wearables that provided one function using sensors to detect stimuli and show or aware the user using measured data without analytical processes that predict a user's physical condition. Previous studies in different areas focused on developing wearable sensing systems for use in specific task environments. However, other processing and technologies are needed to create a similar system that monitors chefs' work efficiencies and analyzes their activities.

Developing a smart chef uniform justified the range of kitchen activities, such as prepping, cooking, moving ingredients, platings, and sending dishes to servers. It also includes recognizing standing to sitting, standing to bend, and standing to walk. As for the type of apparel to attach IoT sensors, the platform selected was a chef jacket because many kitchen activities involve active movement and the convenience of attaching and detaching sensors. If innerwear or bottom wear had implanted wearable systems, the system's sensors and wires could become damaged by continual rubbing against the body.

The configuration of the clothing platform was developed for the comfort of use because the functions of the chef jackets are designed for user convenience, comfort, and safety while performing kitchen activities. As defined in Table 1, the smart chef jacket platforms were designed and developed, so the chefs unnecessarily pay attention to them while working in the commercial kitchen.

The development of the IoT chef jacket focused on the functional standards of kitchen practice, and the design considerations of the platform's shapes are shown in figure 2. Furthermore, oversized outlines are well-matched for wearable platforms, which need space to attach electronic gears to integrate technology.

The chef jacket was designed to install four IoT sensors. The Bluetooth module is positioned on the left side of the shoulder to lessen the use of wires connected to speakers close to the chef's ears. A heart rate monitoring sensor was positioned in the out pocket on the left side of the chest; the temperature module was placed in the left chest out pocket. Table 1 and Figure 2 show the specific functions and positions on the chef jacket.

Table 1: Applied devices in prototype Jacket

Function	Control device	Input device	Output device
Bluetooth Hands-free	Bluetooth Audio module, MH-M28	Embedded Bluetooth classic	Dual speaker
Heart rate monitoring and emergency call	Tiduino processor (shared)	Heart rate sensor, Kong-tech HRM 2 (HM only), Pressure sensor RA30P	SSD 1331 OLED Tiny screen (HM only), Bluetooth, HC-06
Temperature monitoring	Arduini Nano	Temperature-humidity sensor, DHT-11	Embedded Bluetooth, HC-06, heating sheets
Fall detection auto emergency notice	Bluno beetle	Six-axis gyro-accelerator sensor, MPU6050 GY-521	Bluetooth, HC-06
Direction monitoring	Tiduino processor	Bluno beetle	Bluetooth, micro-vibrating motors

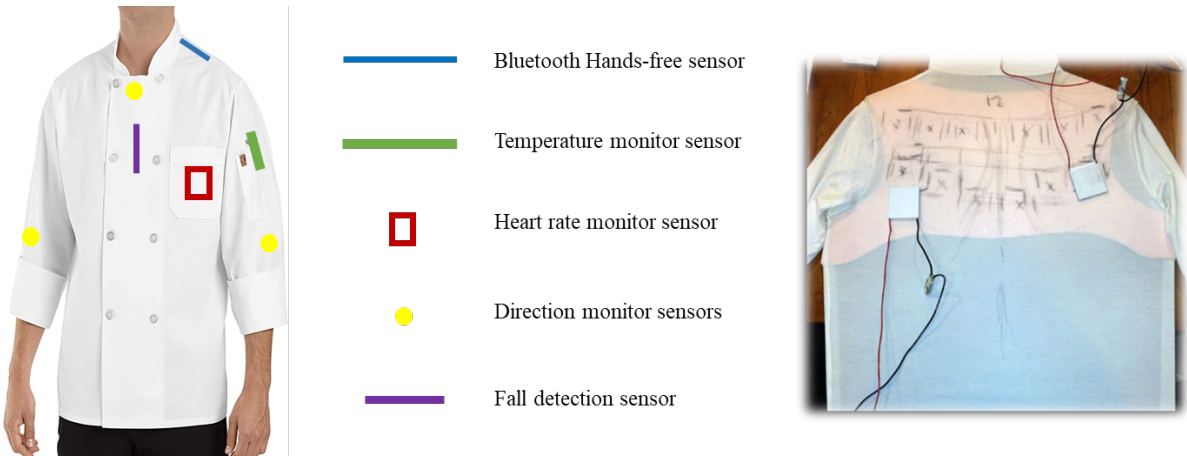


Figure 2: Prototype garment platform

4. Prototype Testing Results

The prototype aims to deliver various functions that ensure the chef's work efficiency and safety. The porotype results are the practical examination of the design and structure of the platform, internal and external operational details, and extensive application. Mainly this study is in the R&D stage, and the new IoT chef jacket focused on clothing design and engineering technologies. Three prototype chef jackets were labeled as X, Y, and Z, and three students were recruited for the study. Tests were conducted in a university's kitchen laboratory to check the usability of the prototype chef jacket. The prototype was tested multiple times to confirm wearability and ease of use.

In stage one, the Bluetooth Hands-free module (BH) function was tested to check its compatibility with the tester's smartphone in the commercial kitchen. The testing confirmed the operative signal of the BH system.

In stage two, the Fall detection and auto-emergency notice (FA) function was tested in two ways. The prototype jacket was initially placed on a dummy and thrown down to determine if a researcher received the emergency call and message sent from the tester's phone. Then, the testers put on the jacket to determine whether the FA responded to the testers' gestures and actions. The results showed that the FA system successfully reacted to the configured actions.

In Stage three, the Direction monitoring system (DMS) testing was conducted when a tester moved in different directions, such as straight behindhand, left, and right, and the researcher checked the smart chef jacket's distance and directions. Then, the researcher investigated the DMS system's compatibility with gathering motion data. The test results inveterated that the DMS system worked effectively as designed.

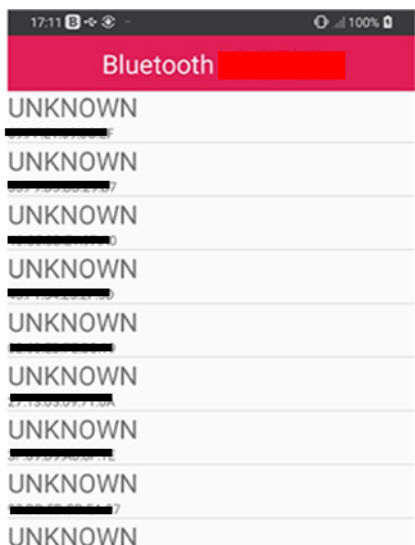


Figure 3: Bluetooth connection screen

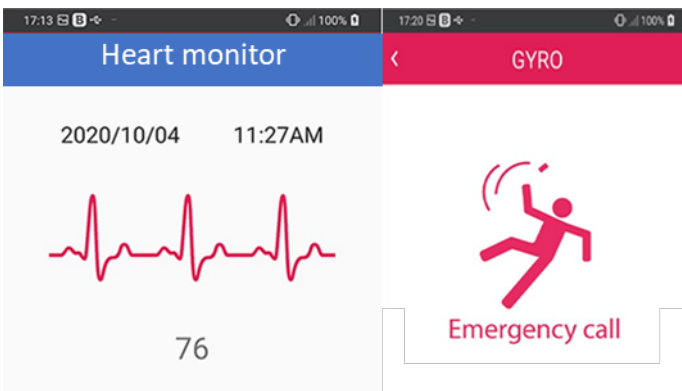


Figure 4: Heart monitor and Emergency call function

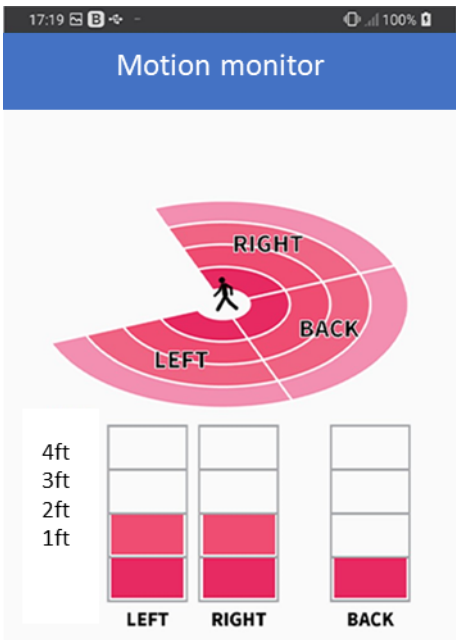


Figure 5: Direction and motion function screen

In stage four, in the Temperature Monitoring (TM) function tests, the accuracy of logged temperature was evaluated by comparing it to an NSF-certified thermometer. The researcher also verified the warning function using a thermometer placed in the chest pocket when the kitchen temperature was above 110 °F, which can be critical to chefs' performance and safety.

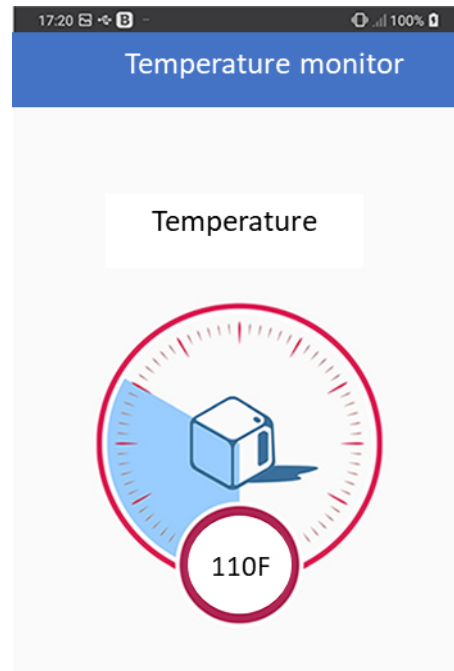


Figure 6: The temperature monitoring screen

In Stage Five, the motion detection (MD) function and the collected data accuracy were compared with a commercially sold smartwatch. The testers wore the smartwatch and the prototype chef jacket, and both units measured their motions while performing various kitchen activities. The results revealed the similarity of the measured values for MD sensors and smartwatches.

After each experiment, the testers filled out a questionnaire composed of a five-point Likert scale (Appendix A). The three testers provided feedback on the garment platform's wearability (4.0), ease of motion (4.1), and operability (4.4). The testers also had an interview to share specific explanations about the prototype chef jacket. The participants commented that the design of the jacket platform and functionality were fitting for kitchen activities to protect the chef's body while cooking. The oversized chef jacket was comfortable for work even though each functional module was distributed across the jacket. Also, the various interfaces to input and output the data were easy to use, and all system components worked as projected.

5. Discussion and Conclusion

The study aimed to develop wearable sensing and wearable IoT chef jacket to deliver reliable and proximate efficiency and safety data through body signal monitoring and activity recognition. The evaluators tested the prototype's wearability and usability through typical kitchen activities. As a result, this study confirmed that the IoT chef jacket prototype offers extended functionality and efficiencies using the IoT system-generated information. Notably, the IoT chef jacket provides three unique pieces of information to assist chefs in improving work efficiencies, monitoring their safety, and responding to emergencies.

This study could be applied to develop wearable systems with extended literature for the kitchen and the other working environment. First, the prototype used the ideas of wearable sensing, context-aware computing, and wearable interfaces, which created data that analyze the user's vital signs, movements, and body position. By shifting the efficiency and safety-focused sensing process, the study also hoped to bridge the possible role of fashion and engineering sciences.

Second, gyro and distance sensing technologies used for the prototype's FA function and the self-directed process could improve recognition ranges and deliver substitute control interfaces that do not rely on the user's visual or auditory input. This improvement could advance wearable sensing with direction-based systems to support aural or visually impaired people in any environment. In addition, wearable IoT systems developments can expand disabled people's lives as they perform their daily activities.

Appendix A

1. Garment Platform	2. Functionality (wearable system)
1–1. The aesthetic-visual balance between the garment platform and the module housings. 1 (Bad) 2 3 (Neutral) 4 5 (Good)	2–1. The wearable system's operating interface (power switch and input interface) (?) 1 (No) 2 3 (Neutral) 4 5 (Yes)
1–2. The usability of functional details, wearability, and body movement activity during the climbing activity. 1 (Bad) 2 3 (Neutral) 4 5 (Good)	2–2. Did you easily check the wearable system's output interface (screens)? 1 (No) 2 3 (Neutral) 4 5 (Yes)
1–3. Did you feel that the system modules (wearable system) disturbed body movements during climbing situations? 1 (Yes) 2 3 (Neutral) 4 5 (No)	2–3. Did you easily perceive and handle the GUI of the smartphone application? 1 (No) 2 3 (Neutral) 4 5 (Yes)
1–4. What was the prototype's total weight, including the garment and the suitability for intense outdoor (climbing) activities? 1 (Bad) 2 3 (Neutral) 4 5 (Good)	2–4. Was the smartphone application effectively operated during mountaineering activities? 1 (No) 2 3 (Neutral) 4 5 (Yes)

Source: Lee, H. et al., 2021

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