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Development of self-defense garment

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Abstract : *There has been a spurt in violence against women of which physical violence tops the chart. This research and consequent product development (self-defense garment) was an endeavor to develop an effective self-defense garment which would provide protection to women in case of any assault or unsolicited contact. This garment uses electric shock as a deterring agent, which immobilizes the assailer for a few moments and thus giving the victim time to escape and/or make a rescue call. Additionally it also has feature to send message for help and rescue.*

Keywords: *Product development; self-defense; smart garment; electrical shock, e-textile.*

I. Introduction

1.1 Problem

Violence against women is a serious problem plaguing the world; the sexual crimes against women remain still a cause of deep concern not only in developing but in the developed world also. According to the World Bank's 2012 World Development Report [1], on Gender Equality and Development, around one in every three women in the world experience physical or sexual abuse at some point in their life. According to the rape statistics released by the National Crime Records Bureau (NCRB) [2], in the year 2012 approximately 80,000 cases of rape and molestation of women were registered in India. Many devices and gadgets have been created in attempt to provide women with self defense mechanism. One of the effective methods has been with the use of electricity.

1.2 Existing Deterring Devices In The Form Of Garment

Self defense wearable garments have been experimented with in the past but suffer from some limitation or the other. Some of the garments are as follows

- No contact Jacket [3]
- Camouflage Dress [4]
- Protective Shield [5]
- Anti-molestation Jacket [6]

1.2.1 No Contact Jacket [3]

Developed by researchers of MIT and Harvard, this jacket (as in Fig 1) has an electrically conductive pathway applied over the body portions, an electrically charged seam construction for producing an electric charge relative to the outer surface of body portion. Activated by a power source, it comes into action once the switch is pressed. There is also a wiring network for producing an electrical association between the conductive pathway and power source.

Limitation: It is not available commercially and manufacturing cost of the jacket is tenatively 1000 USD, thus it limits its accessibility to only a certain class of customers and is beyond the purchasing range of everyone.

Figure 1: No contact jacket

1.2.2 Camouflage Dress [4]

Camouflage Dress: Concept of a Japanese designer Aya Tsukioka, this strange dress as in Fig 2 gets converted into a coverall which resembles a cold-drink dispensing machine.

Limitation**:** Though the concept is interesting, the practical use of the garment is really doubtful as the assaulter may easily figure out the difference. Moreover, the operating time associated is high (2-3 minutes) and so may be rendered ineffective.

Figure 2: Camouflage dress.

1.2.3 Protective Shield[5]

This garment, in the form of a jacket, has been developed by students of NIFT Kolkata as in Fig 3. Made of cotton fabric with metallic rivets all over its surface, the jacket is aesthetically appealing and also functionally evolved. The metallic rivets serve as contact points and are connected, via wires, to the circuit. The battery powered circuit, when operated (using a switch) gives an electric shock when the rivets are touched. The inner surface of the jacket is lined with cotton fabric.

Limitations: Wiring in the jacket is in series; hence even if one of the connections breaks accidently, the whole garment becomes non-functional. The garment can only be dry-cleaned as all the rivets are fixed and the wires are soldered to them. The garment required a special molded component to attach at the back of the soldering to prevent wearer from the electric shock.

Figure 3: Protective Shield

1.2.4 Anti-Molestation Jacket [6]

Garment in the form of a jacket has been developed by the students of NIFT Delhi (Ref Fig 4). This garment works on the principle of a stun gun. Shock is given when metallic contact points on the surface are touched by the assailer. The wiring in the jacket is in parallel hence accidental breakage of a wire doesn't render jacket non functional. The garment has taffeta lining to protect the wearer from the electric

Limitations: Due to movement of jacket along wearer's body, circuit breaks as wires connects to contact points by soldering and metallic core wire circuit impacts adversely the wear ability of the garment. Additionally the jacket styling has its limitation of wear ability in hot weather conditions like India

Figure 4: Anti-molestation jacket

1.3 Objective

This research focuses on a self-defense garment and examines the limitations of the existing self-defense garments and attempts to remove them. Additionally it also has features to send message for help on activation of the circuit.

II. Methodology

Methodology followed for development of self-defense Garment.

- To understand the market demand for a self defence garment
- Studying the current available technology of deterring devices for their techniques and limitations and identifying the most effective method.
- Studying and selection of available raw material for the jacket i.e. Shell Fabric, Lining material, Contact points, Transformer switch, GSM microcontroller and battery unit to create circuitry.
- Selection of garmenting techniques which are effective and commercially viable
- Development of prototype
- Evaluating the functionality and performance of the developed prototypes.

III. Understanding Market Demand

A survey was conducted pan India for women of various age group starting from 13 to understand their concerns regarding safety and requirement of self defense gadgets.

Total of 107 women participated in the survey

Analysis:

- 90 % of the women have experienced fear when they are outside their homes
- 71 % of women have felt threatened more than thrice in their lives.
- 60% are not aware of devices available for their safety
- 90% women are willing to buy a device which can help protect them
- 88% women have phones on which tracking software can run
- 87% women are willing to purchase the devise priced around INR 5000.

IV. Operating Principle Of Self Defence Garment

Garment is inspired by "stun gun" [7], which works on the principle of momentarily shocking the person with a low-voltage pulse delivered between two electrodes. The shock has the effect of temporarily immobilizing the person giving the wearer time to escape.The invertor circuit is in compliance with GSM microcontroller which will send message to pre-defined number when a person gets a shock alerting them about the situation.

V. Raw Material Selection

5.1. Selection of Conductive Thread

The structures of conductive yarn can be categorized into three classes [8] (Ref. Fig.5):

- Metal-wrapped yarn - It is a composite of metal and yarn. A conductive yarn mainly consists of a strand of non-conductive yarn wrapped with one or more metal wires.
- Metal-filled yarns - In this yarn a fine metal wire serves as a core covered by non-conductive fibers.
- Metal Yarn- Metal fibers are prepared in forms of either filaments or staple fibers and processed as a conventional yarn.

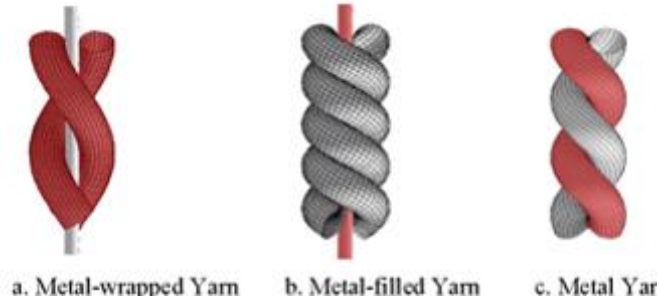

Figure 5: Structure of conductive yarns. Conductive material is shown in red[9].

Various commercially available conductive threads were studied for their properties and comparative table is in TABLE 1.

After exploring properties of conductive yarns [TABLE 1] Yarn selected for product development is stainless steel yarn

Table 1: Comparative table of Properties of the commercially available conductive threads

Parameter	**Aracon yarn** [10]	**AmberStrand® Fiber** [11]	**Shieldex-Silver thread 117/17 x 2ply**[12]	**Shieldex - Silver thread 234/34 x 4ply**[13]	**Lame Lifesaver** [14]	**Stainless Steel Conductive yarns.** [15]
Yarn type	Metal wrapped yarn	Metal yarn	Metal wrapped yarn	Metal wrapped yarn	Metal wrapped yarn	Metal yarn
Yarn count	200 and 400 D	1432 D	252 D	828 D	18 D	820.6 D
Yarn diameter (mm)	0.23 and 0.36	0.25	0.17	0.2	0.05	0.26
Resistance ohm/ft	0.7	2	1200 to 2000	15.2	20	28
Streatchability	Yes	Yes (2.5% ultimate elongation)	No	No	No	No
Price (U.S. $ and shipping excluded)	3 yard/$	N/A	19 yards/$	13 yard/$	10 yards/$	9 yard/$
Operating Temperature range (Celsius)	-65 to 200	-65 to 260	-30 to 90	-30 to 90	-20 to 70	-150 to 300
REMARK	very low resistance high flexibility but expensive Yarns Available only at B2B basis	Very low resistance high flexibility. Yarns Available only at B2B basis	conductivity degrades with time	conductivity degrades with time	conductivity degrades with time	Stainless steel is resistant to oxidation and Oxidation increase resistance of wire. I.e. conductivity of the wire will not hamper by oxidation.
Selection	Not selected	Not selected	Not selected	Not selected	Not selected	Selected

5.2 Selection of Shell &Lining Material

For shell and lining, water resistant fabric constructed from insulation materials is desired as it will have to protect the wearer form back flow of the current and short circuits, various Insulation materials were studied and comparative table is listed below[16] in [TABLE 2]

The materials were compared on

Resistivity of the materials – as it indicates electrical resistance of the material.

-Surface resistivity - Surface resistivity determines the electrical resistance of the surface of an insulator material. It is measured from electrode to electrode along the surface of the insulator sample. Since the surface length is fixed, the measurement is independent of the physical dimensions (i.e., thickness and diameter) of the insulator sample. More the value, less will be the current flow according to ohm's law.[17]

-Volume resistivity as determine the electrical resistance through a cube of insulating material. When expressed in ohm centimeters, it would be the electrical resistance through a one centimeter cube of insulating material. If expressed in ohm inches, it would be the electrical resistance through a one-inch cube of insulating material. More the value less will be the current flow according to ohm's law.

-Fabric Construction/Finish – as it indicate air permeability / water resistance parameters of the material.

Table 2: Comparison table of properties of Insulation materials

Material	**Formula**	**Surface resistivity Ohm/sq**	**Volume resistivity Ohm/cm**	**Fabric construction**	**Remark**	**Selection**
Polyamide - Nylon 6	PA 6	$5*10^{10}$	$5*10^{12}$	Single jersey knitted fabric. Water repellent finish	Easily available Strong fabric resistant to wear and tear Water resistant so will not let sweat of wearer affect the circuit Air permeable.	Selected for lining
Ethylene-Tetrafluoroethylene Copolymer	ETFE	$>10^{14}$	10^{16}	Not use to make fabric	ETFE is not use for fabricating clothes.	Not selected
Polytetrafluoroethylene	PTFE	10^{17}	10^{18}-10^{19}	Use as breathable and water repellent layer.	Use to make gore-tex breathable fabric. Available only at B2B basis	Not selected
Polyethylene terephthalate	PET	10^{13}	$>10^{14}$	Plain weave fabric. Water resistant finish.	Water resistant Non-breathable and non-air permeable	Selected for shell

VI. Prototype Development

This device-cum-garment has two components – Functional Component and Aesthetic Component.

6.1. Functional Component of the garment

Functional component comprise of the operating technology of the garment which includes invertor circuit, GSM microcontroller and network of conductive yarns for delivering shock.

The circuit is an inverter circuit [18] having transformer powered by a 12 Volt A.C. producing an AC output of 110V and 15– 30mA current. Circuit is connected with embroidered conductive yarns on the surface of garment. The wire circuits are in parallel so that in case of accidental breaking of circuit the garemnt is not rendered non-functional. The charge is delivered to the surface of the garment through embroidered conductive yarns on the surface. A hidden switch activates the circuit, when pressed, delivering the charge to the conductive yarns on surface of the jacket and GSM microcontroller actuates via light activating switch to send SOS message to predefined phone numbers.

The conductive lines have been placed at a distance from each other to ensure maximum probability of contact as shown in Fig 6. The jolt will be delivered if both terminals of wires are touched by the assailant while the circuit is activated. The conductive yarn lines have been placed judiciously in such a way that it gives maximum coverage to the wearer without resulting in short circuiting by accidental touching of the conductive lines.

Figure 6: Close view of conductive thread trace

6.2. Aesthetic Component of the garment

It comprises of insulation materials and the styling of the cape Cape is a layered garment having two layers of textile material. Garment works on the principle of giving electric shock to the assailer though the embroidered conductive yarns on the outer surface of the product. The inner lining is made up of waterproof and semi breathable material so besides providing insulation it can provide comfort to the wearer.The garment is very light and can be used in summer as well as winters because of breathable silhouette. Due to the design of the garment it can be worn over any garment. There are no sleeves in the garment thus minimising the chances of the garment short circuiting due to contact between conductive surfaces. Front and back view of garment are in Figure 7&8 .The entire garment is potentially a conductive surface because of the embroidered threads. The button is in a pocket placed at right bottom on the surface of lining fabric and is easily accessible and can be activated quickly as shown in figure 9 .Figure 10 shows the Close view of activation control area and is located at lower right of front panel. This cape can be machine washed.

Figure 7: Front view of self defense garment

Figure 8: Back view of self-defense garment

Figure 9: Placement of pocket and switch

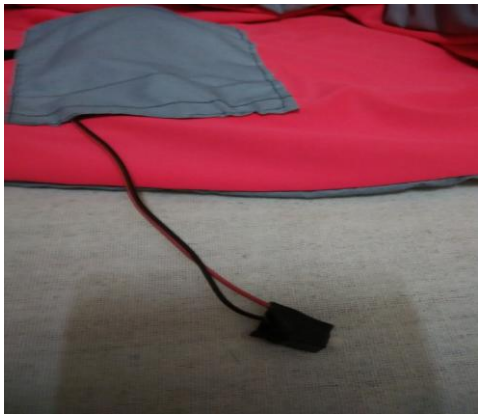

Figure 10: Close view of activation control area

VII. Conclusion

The developed garment gives out a mild electric shock to an intruder. The garment device has a GSM microcontroller installed into it which will send message to pre-defined number alerting them about the situation when a person gets an electric shock. All the wires forming the conductive surfaces are connected in parallel. The outer layer of the garment is waterproof .The garment silhouette is breathable. The inner layer of the garment is waterproof and air-permeable providing comfort to the wearer. The weight of the garment is just under 500grams including the circuit .Another important factor for the safety of the wearer is that the garment does not have any sleeves it is merely worn over the body which means it can be put over any day to day clothes and also there is less chance of the wearer getting an accidental shock. The circuit of the garment is completely detachable which means it can be washed easily. The garment does not have any soldering anywhere in the body which gives increases the resistance of the garment to wear and tear. Sampling cost of self-defence garment is approximately INR 3000.

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