# Smart Interactive Textile System


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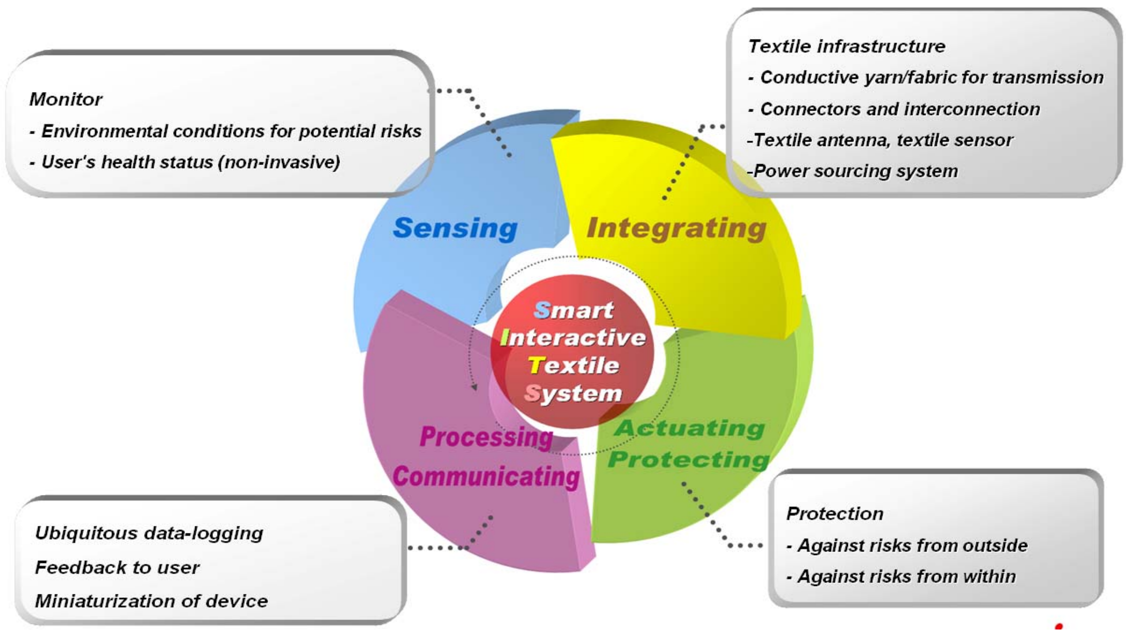
A Smart Interactive Textile System (SITS) is a fabric- or textile-system that responds to or interacts with environmental or electrical stimuli. Certain reactions to these stimuli may include conducting, transferring, or distributing various properties through the material or across the membrane of the material, such as, electrical current, light energy, thermal energy, molecular or particulate matter. In some cases, physical characteristics or phases may be changed, such as color, shape, size, rigidity, porosity, or permeability.

In this way, SITS provides an intelligent environment to it's users by protecting the wearer from harmful environmental conditions and the wearer's own health problems. To deliver these benefits of safety and comfort to the users, miniaturization of health monitoring tools and protective systems and their integration into flexible textiles should be achieved.



# Technical Objectives

## 1. Sensor Technology

To realize smart fabrics or interactive textiles, physical detection sensors such as respiration, ECG, temperature, posture sensors and biochemical detection sensors such as blood glucose, sweat rate sensors have been developed by several research groups. Because the sensors should be incorporated in the garment unnoticeable to the wearer, an important property for sensors applied in this field is flexibility. As a fabric based biophysical monitoring solution, a piezoelectric poly(vinylidene fluoride) film sensor coated with silicon was developed for respiration and pulse detection. The mechanical to electrical conversion of the piezoelectric PVDF film sensor is used as the voltage source to detect pressure, load, acceleration, and strain. Changes in girth during respiration generate voltage variation in the PVDF film sensor wrapped around the chest or abdomen. This variation is monitored as a function of time using voltage mode amplification circuitry. Respiratory monitoring of a patient under sedation using a PVDF film sensor was carried out.

A fabric based conducting polymer composite sensor can detect environmental conditions for potential risks such as toxic chemical gases. PANI-Nylon6 composite fabric obtained by *in situ* polymerization is an attractive alternative for gas sensing applications. The electrical resistance of the composite fabric increased when exposed to ammonia gas but reversely recovered after flushing with fresh air. Among the dopants tested, formic acid doped PANI-nylon6 composite fabric provided the best sensing property for $NH_3$ gas.

## 2. Data Processing & Communication Technology

Ubiquitous data-logging and monitoring can be realized with an interactive textile based information processing system via advanced wireless technology. Bluetoooth and wireless LAN are convenient technologies, and for this purpose an integrated textile antennae will be essential. The user can get feedback on one's conditions and be alarmed by visual or audio means. For concealed, portable, lightweight continuous monitoring with low power consumption, miniaturization of the devices is important.

Electronic jackets coupled with iPods or cell phone devices, electroluminescent textile displays, textile-based microphones and biophysical monitoring garments are examples of interactive textile based information processing systems that are currently offered commercially.

## 3. Actuation and Protection Technology

As a part of actuating and protecting technology for SITS, instantly hardening materials as protection against projectiles, active cooling or heating textile materials and EMI shielding metal composite fabrics are currently under research. Liquid armor utilizing magnetorheological fluid(MRF) and shear thickening fluid(STF) on fabrics were investigated. Rheological and mechanical properties of these systems were investigated and analyzed by simulations based on the 3-element viscoelastic yarn model.

The possibility of the active cooling e –textile system using Peltier effect was investigated.

Metal yarn composite textiles were weaved in various formations and their functionalities were evaluated. Silver plated copper and stainless steel filaments of 40μ or 35μ in diameter were used. EMI shielding effectiveness and thermal comfort factors of copper/polyester and stainless steel/polyester composite textiles were measured and evaluated. EMI shielding effectiveness was tested in the frequency range of 500MHz ~ 1.5GHz. Metal type, insulating coating on the metal filament, metal yarn volume fraction, metal yarn openness, and the aspect ratio of the openness all affected the EMI shielding effectiveness. Metal type and insulating coating affected the EMI shielding effectiveness as well as shielding characteristics. Metal composite fabrics with same openness but different aspect ratio of the metal yarn open grid had similar EMI shielding effectiveness in average but showed distinct frequency dependence.

## 4. Integrating Technology

For SITS to be realized, inter-connections among the sensors, actuators, power source, data processing device and communication device must be established through a textile infrastructure. Textile processing aspects such as spinning, weaving, knitting, embroidery and finishing technology are adapted for the production of conductive textiles to form the base of this infrastructure.

A conductive composite sewing thread to be used as a textile transmission line in interactive textile systems was developed. This electrically conductive sewing thread is composed of insulated metal filaments and polyester yarns and produced on standard textile-processing equipment. Thus, it has practical advantages such as low cost and an easy application. One can just sew a transmission line onto a fabric where ever needed. The electrical and tensile characteristics of this thread were studied.