Core-Body Temperature Acquisition Tools for Long-term Monitoring and Analysis

João M. L. P. Caldeira[1,2], Joel J. P. C. Rodrigues[1], José A. F. Moutinho[3], Marc Gilg[4], and Pascal Lorenz[4]
[1] *Instituto de Telecomunicações, University of Beira Interior, Covilhã, Portugal*
[2] *EST, Polytechnic Institute of Castelo Branco, Castelo Branco, Portugal*
[3] *Health Sciences Faculty, University of Beira Interior, Covilhã, Portugal*
[4] *IUT, University of Haute Alsace, Colmar, France*
jcaldeira@it.ubi.pt, joeljr@ieee.org, jafmoutinho@fcsaude.ubi.pt, marc.gilg@uha.fr, lorenz@ieee.org

***Abstract*— The detection of fertile and ovulation periods may be performed by women's body temperature variations. These variations are more accurate if a core-body temperature for their detection is used. Previous medical studies concluded that the use of skin temperature could be influenced by environmental conditions. Since the increasing of the body temperature in this period is only about 0.5 ºC, it is crucial that measurements should be the most accurate as possible. Due to the lack of solutions to realize that in order to measure and analyze the core-body temperature, this paper presents a system to capture, display, and monitoring core-body temperature. It is considered a hardware solution (sensor) to be placed inside cervix and a computer application to communicate and gather the collected data by the sensor. Bluetooth is used to perform the communication between a computer and the sensor. The system evaluation is performed by a medical team in several volunteer women. Furthermore, the collected data by the sensor may be used to study the relation between temperature variations and women health conditions.**

***Keywords*— Biosensor; Wireless sensor network; Biofeedback; e-Health; Temperature Monitoring.**

I. INTRODUCTION

New technologies applied to healthcare and biofeedback improves the traditional way of medical procedures. Recent publications [1-3] report continuous evolution and progress of new biosensors for healthcare and biofeedback. These sensors became indispensable in the daily routine of medical staff where they have the capability for helping medical procedures and healthcare. Nowadays, biosensor systems are powerful available instruments in diagnosis, controlling, monitoring and prevention of some diseases [4, 5]. In some cases, they also became an essential instrument for heal support [6-8].

The evolution of these biosensors offers a new range of the infinity possibilities for applications they can provide. The miniaturized size of these nodes turns these systems more easy to use, in a comfortable way. They can access to inside-human body places that were difficult to reach and non comfortable for patients, using traditional methods [9]. Advantages of these systems and the great interest of medical community turn this research area as an important topic.

The human body temperature is one of the most controlled bio-parameters because it reflects some health conditions through its variations. Monitoring this human parameter may improve healthcare on patients suffering from pathologies that could be controlled by body temperature regulations. In women this parameter is also correlated with fertility stages. The increasing of regular core-body temperature by about 0.5 centigrade degrees (ºC) probably indicates the occurrence of a fertility period. Therefore, monitoring this parameter becomes an excellent method to predict this period [13]. The acquisition of core-body temperature in women is crucial for the validity of the monitoring procedure. Digital thermometers are highly used for temperature measurements acquisition. This method is very inappropriate for active women that have to measure their core-body temperature at specific hours, in order to establish standard patterns. Therefore, this method also could lead to wrong measurements caused by rapid execution of the procedure and inappropriate handling of thermometers. The use of standalone systems could suppress the women intervention to collect this parameter. Although, these systems improve the quality of the collected values because they are less prone to bad handling that may lead to wrong measures.

This paper proposes an integrated system for long-term data acquisition, processing and analysis of cervix women's temperature. The system comprises three modules. First module is the temperature sensor (thermistor) it self. It is placed inside women body, close to the cervix. The second module is the processor unit responsible for data acquisition and long-term collection of the temperature values. Finally, the third module is a computer application software, used to operate the biosensor, and for representation and control of the intra-body temperature measured values.

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This study is a joint work with physicians from the Health Sciences Faculty of the University of Beira Interior, Covilhã, Portugal. This new biosensor allows the execution of exploratory studies to increase the knowledge of female intra-vaginal physiological behavior. To perform this study, medical team wants to monitor and analyze the intra-vaginal temperature during the female menstrual cycle. Furthermore, they will use this new system for the following applications: preterm labor prevention, detection of pregnancy contractions, anticipation and monitoring of the ovulation period (for both natural contraception and *in vitro* fertilization purposes), effectiveness of some gynecology therapeutics, and supporting the discovery of new possible contraception methods. These system applications will be conducted taking into account previous medical studies where this physiological parameter (the temperature) is correlated with several human phenomena [10-12], including female fertility issues [13]. This confirms the importance of the contribution presented in this paper.

The remainder of the paper is organized as follows. Section II elaborates on some available projects carried out on this topic. Section III describes the new biosensor and presents the system architecture and the construction of the biosensor firmware including the used communication mechanisms is presented in Section IV. In section V, the intra-vaginal temperature monitoring computer application is presented, focusing in its construction and validation. The biosensor validation and results are presented in Section VI. Finally, Section VII concludes the paper and points further research directions.

II. Related Works

Research on healthcare has been striving to find relationships between core body temperature at female genitals and certain health conditions, such as ovulation period. A study presented in [10] concludes that exists a correlation between covert attention and basal temperature changing during the menstrual cycle phase based on 22 adult females and proved the importance of basal (intra-vaginal) temperature. In this study, a traditional way was used for temperature measurement. However, automatic measurements and analysis of intra-vaginal temperature readings in an unobtrusive and efficient way are desirable.

One of the earliest known projects for vaginal temperature measuring was presented in 1994 [14] and 1996 [15]. The system needs a permanent radio-frequency connection to a computer. The computer receives all the temperature measures and collects them. The sensor itself cannot store the measured values. This limitation imposes the sensor must be near to a personal computer and it difficult the mobility of the monitored woman. The use of mobile systems frees women to follow their regular daily life always under monitoring. Although, if a sensor itself cancollect the temperature measures in long-term way, it is dispensable a permanent connection to any device which improves the sensor's battery lifetime.

Another study uses a radio pill created for astronaut use, to access internal body temperature on athletes, and take measures to cool them down, avoiding excessive fatigue [16]. However, such pill-based solution introduces issues on pill elimination, and the biosensor cannot be reused again.

Other medical studies about developing integrated systems to acquire and monitor physiological parameters, including body temperature [7, 17]. These systems only measure the skin temperature. From [11] one can conclude that skin temperature cannot reflect the basal body temperature as it changes depending on the environment temperature. The AMON research team included a temperature sensor on their wearable system (AMON) [7] to study a possible correlation between the skin temperature readings by the sensor and the core body temperature. They concluded that skin temperature could be influenced by the environment conditions. Therefore, they could not show any correlation between skin temperature and core body temperature.

DuoFertility project [17] created a system to predict women fertile period. This system bases its prediction on the measurement of skin temperature. During fertile period, the variation of women core body temperature occurs around 10-14 days of menstrual cycle. It only changes about 0.5 degree Celsius [13]. Thus, trying to get core body temperature by measuring skin temperature could lead to wrong interpretations and conclusions.

In [18], the authors presented a system using UHF radio telemetry to measure the vaginal temperature and monitor the temperature. Another approach, presented in [19], the author proposed a highly accurate system where a capsule shaped sensor measures the central body temperature. This sensor can be ingested or inserted rectally such that it will transmit core body temperature continuously.

A method for detecting and predicting the ovulation and the fertility period in female mammals is described in [20]. This method provides information relating the fertility of females mammals. It comprises the following steps: (*i*) takes multiple temperature readings from the female mammal during an extended period; (*ii*) identifies and disregards temperature readings having one or more characteristics of irrelevant or faulty data; (*iii*) obtains one or several representative temperature values for the extended period; (*iv*) repeats steps from (*i*) to (*iii*) over multiple extended periods; and (*v*) analyzes the representative temperature values obtained over multiple extended periods for one or more patterns in the representative temperature values. It

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indicates or predicts the ovulation in order to provide information related to the fertility of the female mammal. This method only describes a procedure to get temperature measurements for fertility purposes in female mammals and not really a hardware system that may allow this operation.

Next sections present, in detail, the construction of the new intra-vaginal temperature biosensor, and the corresponding application and communication system. This system deploy results on a personal computer for monitoring and further analysis.

III. INTRA-BODY BIOSENSOR

Sensing is fundamental to all sensor networks, and its quality depends from many factors such as size and used materials.

Body sensors measure core body temperature, ambulatory blood pressure, blood oxygen etc. As the accurate measure of core body temperature is highly preferred in numerous medical applications, intra-body biosensor is required. The main challenge is the construction of a novel intra-body biosensor for intra-vaginal temperature monitoring. Furthermore, the intra-body biosensor must consider the sensitivity of the body area, critical for the comfort of the user on a daily basis.

This proposal falls in the conception of a novel biosensor device to measure intra-vaginal temperatures and continuously gather their measurements for further analyses purpose. To access and analyze all data collected by this intra-body biosensor, a new application was also developed.

This biosensor uses a SHIMMER platform (Sensing Health with Intelligence Modularity, Mobility and Experimental Reusability). It is a wireless sensor platform designed by Intel and can be used as the central processor unit of the biosensor network. This platform has a Texas Instruments MSP430 CPU (8MHz), a class 2 Bluetooth radio communication, an IEEE 802.15.4 Chipcon wireless transceiver (2.4GHz), a 3-Axis Freescale accelerometer, a MicroSD slot for up to 2Gbytes, an integrated Li-Ion battery management and some extensions to append new features and functionalities mounted in a very small form factor (2 x 4.5 cm) not larger than a thumb size. This platform is an ideal hardware for this work due to its small size, large data storage capacity and communication features. However, there is no temperature sensor installed on SHIMMER platform. In order to get temperature readings, a temperature sensor must be integrated on SHIMMER. Thus, the MA100 thermistor from GE Industrial Sensing is used on this solution. Its sensitivity ranges from 0 to 50 degree Celsius, size is 0.762 x 9.52 mm, and is created for biomedical applications. MA100 is connected to the SHIMMER with a flexible cable.

Due to its bulky size, is not possible to place SHIMMER inside the female cervix. Therefore, only MA100 thermistor is introduced inside the vagina and sends measurements (in voltage) to SHIMMER, using a flexible cable. The SHIMMER unit stays outside the women body and could be placed anywhere if the cable is long enough (~ 80 centimeters). As the cable is very flexible and difficult to handle inside the female cervix, a tampon-like enclosure was created for the biosensor. This solution allows that women can easily introduce the tampon-like enclosure with temperature sensor inside body because it can be used as ordinary tampons.

Figure 1 presents the proposed system architecture. The temperature sensor (MA100) is placed inside cervix, while the processor unit (SHIMMER) remains outside. Bluetooth performs the communication between this device and a computer.

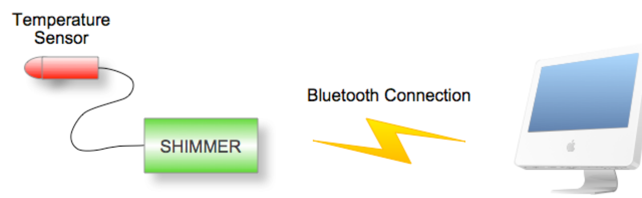

Figure 1. System architecture.

To ensure the acquisition and storage of the read temperature values, a SHIMMER firmware was developed. This software, running in continuous mode, is waiting for personal computer commands over a Bluetooth connection. Once a command is arrived, SHIMMER analyzes it and proceeds in accordance with it. The available commands in SHIMMER firmware are the following: start collecting the temperature values and save them on a microSD, stop collecting, turn on a red led (for debugging purposes), programming the interval between temperature readings and send all the recorded data in microSD to a personal computer application.

Valuable results can only be collected if a correspondence between the measured temperature and the exact time it was acquired may be identified. SHIMMER has a local time clock starting on the startup time, however it does not have a global time clock. In order to provide a global time clock on SHIMMER, when a computer performs a start collection command, it also sends its time and date to SHIMMER (assuming that computer clock is synchronized with global time clock). This information is used on SHIMMER, regarding its local time, to calculate the global time clock associated with each measure.

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The proposed biosensor is presented in Figure 2. Figure 2(a) shows the MA100 thermistor in its enclosure. The SHIMMER platform and the external extension where MA100 is connected may be seen in Figure 2 (b).

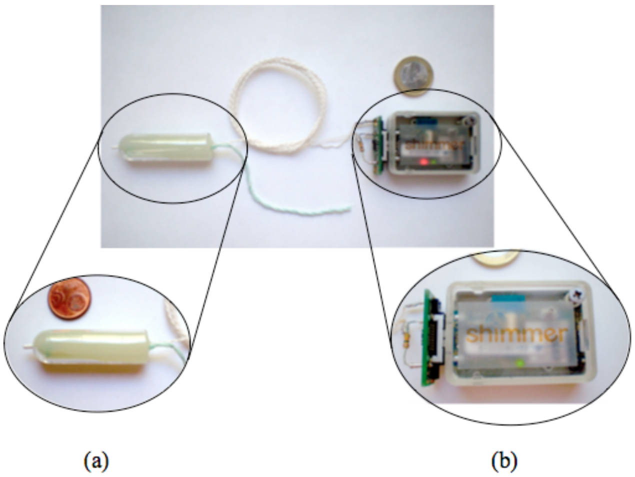

Figure 2. Biosensor for intra-vaginal temperature collection.
(a) Temperature sensor (MA100) with enclosure; (b) SHIMMER platform.

IV. Communication Tools

Although SHIMMER is a powerful biosensor platform with all the above-described features, it has very limited resources in terms of computation and is very dependable from a power battery with no long lifetime. In order to ensure increase of the battery lifetime, only temperature readings from SHIMMER are gathered, instead of collecting and processing them. Temperature readings are transmitted to a computer and collected by an application for further processing and analysis.

Bluetooth performs the communication between SHIMMER and a personal computer. Wireless communications seems to be more realistic than other wired alternatives, taking into account patients comfort and operation simplicity by medical staff. Like any body area sensor network, it is unique and it attempts to restrict the communication radius to the body's periphery. Limiting transmission range reduces a node's power consumption, decreases interference, and helps privacy maintenance.

The connection between the biosensor and a computer is only available if the sensor is in Bluetooth's connection range to the computer, as expected. Because of that, an effective monitoring of the temperature values cannot be performed if the sensor is out of range. Therefore, in case of communication failure between SHIMMER and a personal computer, SHIMMER only collects temperature and saves temperature readings on its local microSD. Then, it can transmit them when a Bluetooth connection is active. This procedure prevents unnecessary use of power to perform the communication and increases battery's lifetime. Figure 3 shows a diagram of Bluetooth data transmission presenting the procedure performed in case of existence of an active Bluetooth connection, or not.

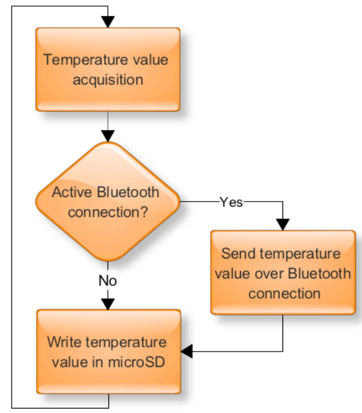

Figure 3. Diagram of Bluetooth data transmission, existing an active connection or not.

To operate with SHIMMER, several commands were implemented. The computer sends these operating commands to SHIMMER, which in turn, sends information and data to the computer. SHIMMER always waits for computer commands over a Bluetooth connection. Once SHIMMER receives a command, it proceeds accordingly. The operating commands available on SHIMMER are the following:

- *Start*: when SHIMMER receives this command, it starts collecting temperature measurements in the microSD card. If a Bluetooth connection continues available temperature measurements are also delivered to computer for real-time monitoring and analyses. If no connection is available, temperature measurements are only written in a microSD card. That way, SHIMMER prevents unnecessary use of Bluetooth connection and allows increasing the battery lifetime.
- *Stop*: this command stops the collection of new temperature measurements.
- *Get*: this command performs the transmission of all temperature measurements stored on a microSD card to the computer application for further study and analysis.

Figure 4 presents the diagram of the SHIMMER's operating commands.

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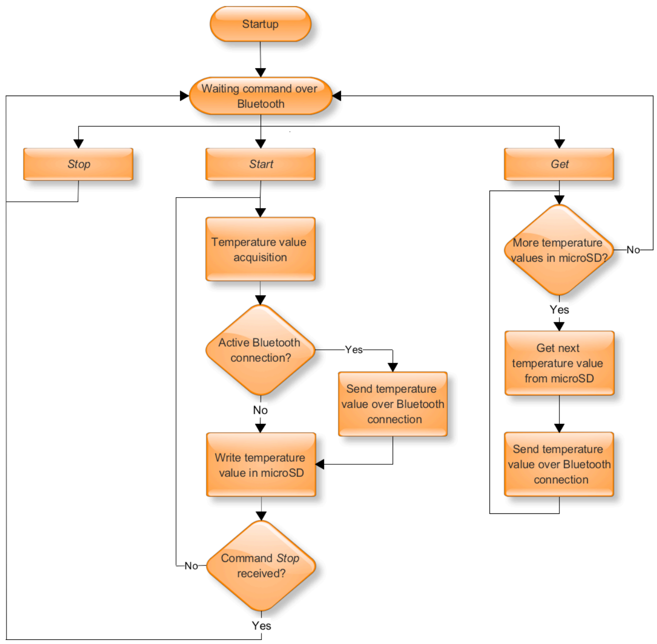

Figure 4. SHIMMER's operating commands diagram.

The analysis of temperature measurements is performed in off-line mode. To ensure good results, as above-mentioned, it is extremely important to know the exact time when each temperature measurement is taken. SHIMMER only has a local time clock, which starts on SHIMMER's start up. To align each measurement with the right global time clock, when a *start* command is sent to SHIMMER, computer also sends its time and date (assuming computer clock is global clock synchronized). This information is then used by SHIMMER's firmware as an offset to local time clock in order to calculate the exact global time clock for every instant of temperature measurements.

V. COMPUTER APPLICATION

A. Application Software Construction

This section describes the created application for collecting, processing, analyzing and visualization the acquired raw data performed by the intra-vaginal sensor in a personal computer. To achieve intra-vaginal sensor temperature values, both real-time and off-line operation modes are available. In the real-time mode, measured values can be achieved when SHIMMER is Bluetooth connected with a computer. In this case, the application software shows the real-time temperature values measured by SHIMMER. Simultaneously, all the temperature measures are sent to the connected computer, via Bluetooth, and at the same time written on the microSD card of SHIMMER platform.

In the off-line mode, the application software can collect all the long-term temperature readings stored in the microSD card. The application software can retrieve all the stored data on the SHIMMER's microSD card. These data may be both visualized and saved in a text file for further use, if needed.

Figure 5 shows de Use Case Diagram of intra-vaginal temperature monitoring application. This use case represents the interaction of the user that can be a physician with this application.

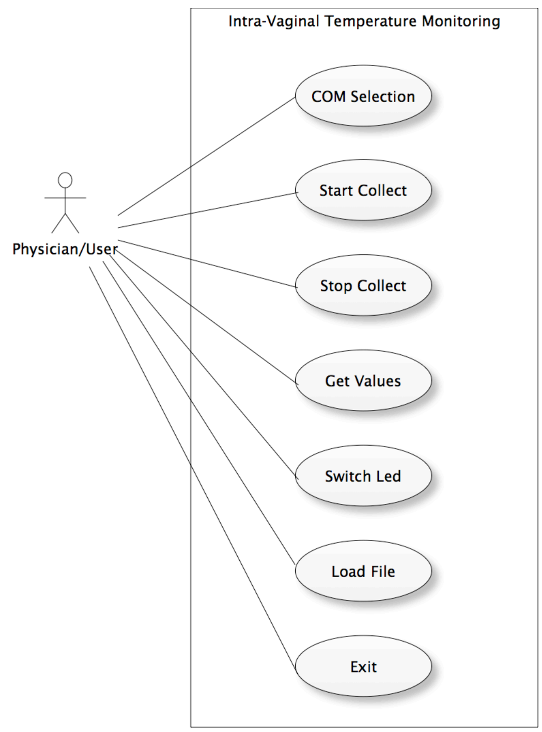

Figure 5. Use case diagram of the intra-vaginal temperature monitoring application.

The description of each use case presented in Figure 5 is the following:

- *COM selection*. This use case allows the physician to select the serial port used for SHIMMER's Bluetooth communication. The selection is performed in a combo box with a list of all the COM ports associated with the SHIMMER platforms paired with the computer. This operation creates two threads. One (*SimpleWriteRead*), is responsible for the communication between SHIMMER and a computer. The other (*GraphTempRT*), represents the real-time temperatures graphic if the intra-vaginal sensor is already in collecting measures mode.
- *Start Collect*. This operation initiates the collection of temperature readings in real-time mode. It creates a *GraphTempRT* thread to represent the real-time graphic temperatures. This operation also

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sends to the *SimpleWriteRead* thread a command to be sent through Bluetooth to the sensor's firmware for initialize the temperature measures collection. The temperature readings are then returned from the SHIMMER to the *SimpleWriteRead* thread and are synchronously represented by the *GraphTempRT* thread. The synchronization is needed to allow the integrity of the represented values in a graph – it only goes to the next one if the previous is already presented.

- *Stop Collect*. The *SimpleWriteRead* thread sends the stop collecting command to the SHIMMER over the air. This action also terminates the *GraphTempRT* thread.
- *Get Values*. This action creates a *GraphTempOL* thread to present the graphic representation of the temperature values received from the SHIMMER. A *Get* command is next sent through Bluetooth connection from *SimpleWriteRead* thread to the SHIMMER platform. In return SHIMMER sends all the temperature measures in the microSD to the *SimpleWriteRead* thread. The *GraphTempOL* thread synchronously presents all the measured values retrieved by SHIMMER. Finally, when all values are returned and represented in off-line graph the *GraphTempOL* thread terminates.
- *Switch Led*. This operation is used to confirm if the Bluetooth serial connection between a computer and the SHIMMER platform is working. If the connection is established this operation switches a red LED in SHIMMER. This operation sends the switch LED command from *SimpleWriteRead* thread to the SHIMMER over the air.
- *Load File*. This feature allows an user (physician) to load temperature values from a file. This operation creates a *GraphTempOL* thread used to design the temperature graph of the values read from a file. These values are represented synchronously, and after all the values in the file are presented the *GraphTempOL* thread terminates.
- *Exit*. This action concludes the application execution. Therefore *IVSoftwareJFrame* thread is terminated and consequently the application itself.

Figure 6 presents the class diagram of the computer application for intra-vaginal temperature monitoring.

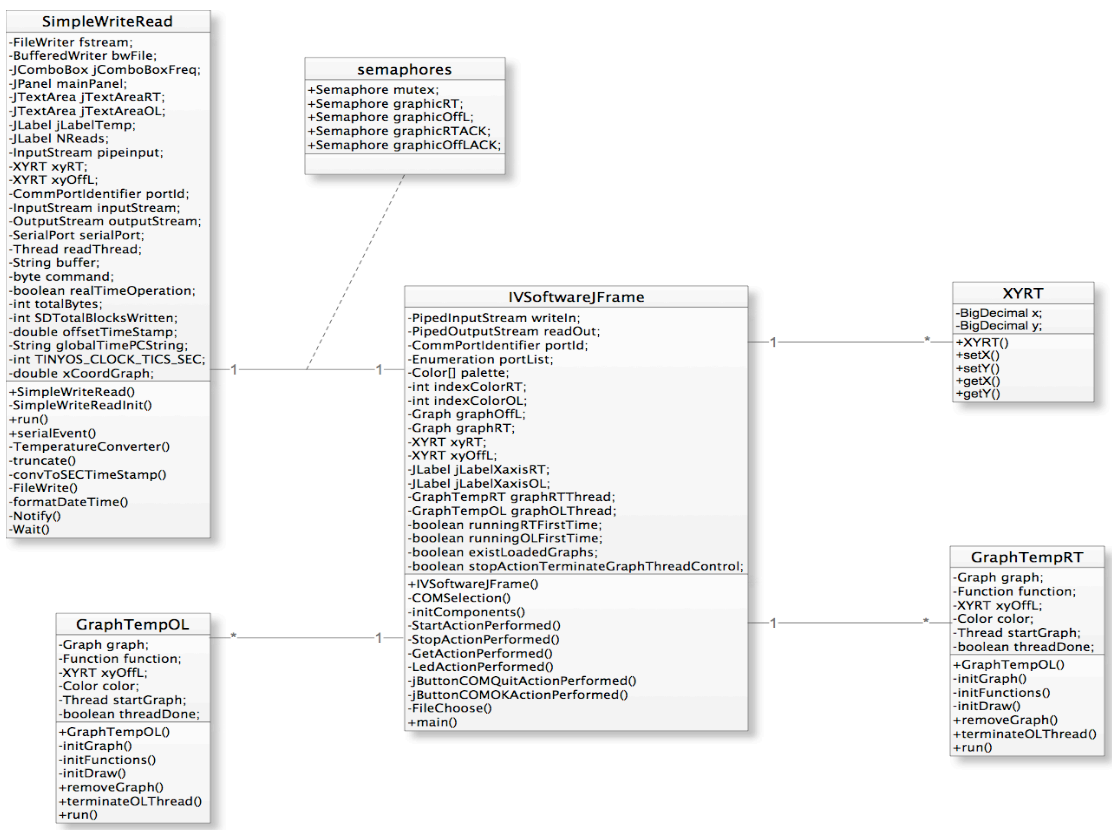

Figure 6. Class diagram of intra-vaginal temperature monitoring application.

B. *Intra-Vaginal Temperature Monitoring Application*

Figure 7 shows the main user's interface of the computer application software. Here, several options are available to configure and interact with SHIMMER platform. This interface also provides a visualization area of graphical temperature readings performed by SHIMMER, in both *real-time* and *off-line* modes.

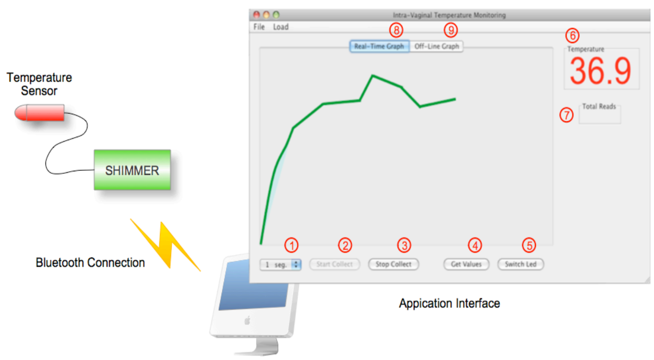

Figure 7. Main window of the intra-vaginal temperature monitoring application.

When the user's interface is open, the *Start Collect* operation is disabled. This behaviour is defined to protect system in such a case that intra-vaginal sensor is already in collection mode. In that mode, if a user starts another collection all previously collected data will be lost. In this case, a *Stop Collect* operation must be firstly performed to guarantee that if sensor is in collection mode no data will be lost accidentally by performing a *Start Collect* operation inadvertently. The intra-vaginal sensor accepts a *Stop Collect* operation *i*) if the sensor is in collected mode, it stops the acquisition of data; and *ii*) if the sensor is in standby mode it is ignored and nothing happening. After performing *Stop Collect* operation the *Start Collect* operation is unblocked.

Below, all the functionalities performed through this window are described in detail.

Definition of Frequency Interval for Measures Acquisition

This feature is performed by the selection of one of the available time values in a combo box identified by ①. This value is used to define the frequency interval of temperature values collected by the sensor. Due to the fact that *Start Collect* operation sends the selected frequency from this combo box to the intra-vaginal sensor, this selection must be performed before each start operation. In acquisition mode, red SHIMMER's LED flashes at each new measure acquisition.

Start Collect operation

The *Start Collect* (②) operation is used to start the acquisition of temperature measurements from the intra-vaginal sensor. This operation also sends to the sensor the current date and time of the computer and the data collection frequency above-described. To perform a *Start Collect* operation, SHIMMER must be in a standby mode. Observing the colour LEDs in this device it can be identified its mode. Green LED *ON* and orange LED flashing indicate standby mode.

Stop Collect operation

Stop Collect (③) operation stops the acquisition of temperature measurements. This operation performs a transition from SHIMMER acquisition mode to standby mode.

Get Values operation

Get Values (④) operation performs the transmission of all stored values in the microSD to the application software. This operation also saves data collected to a text file. This file can be used for persistent storage. When SHIMMER is performed to a *Get Values* operation red LED flashes quickly.

Switch Led operation

Switch Led (⑤) operation is used to verify if SHIMMER is connected to the intra-vaginal application or not. If so, each time a user uses this command, red LED must switch *ON* and *OFF*. Otherwise, if red LED does not switch, this means that SHIMMER is not well recognized by the application. In this case the user should close the application and start again. If the problem persists COM port selected probably is not the one associated with this SHIMMER platform, or SHIMMER could not be well paired with the computer. The user should repeat these configurations and try again the application.

Temperature Information

The label *Temperature* (⑥) is used when SHIMMER is operated in real-time mode and if it is in Bluetooth detection area of a computer. This information field shows the current measured temperature acquired by SHIMMER.

Total Reads Information

The label *Total Reads* (⑦) informs about the number of collected temperature measures stored in the microSD. This information is updated each time *Get Values* operation is performed.

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Real-Time Graph

The *Real Time Graph* tab (⑧) is used when a *Start Collect* operation is performed. If SHIMMER is in Bluetooth detection area this field represents a real-time line of temperature measurements. The graph is updated each new measure.

Off-Line Graph

Off-line Graph tab (⑨) presents the temperature graph of all collected temperature measurements stored in the microSD card. This field is filled when a *Get Values* operation is performed.

Load Menu

Load Menu option is used to load saved text files with previous temperature measures into the *Off-Line* tab field. This feature helps on analysis of collected data by the comparison with previous patterns. Various files could be loaded. A different colour line of the graph represents each loaded file.

The proposed application interacts directly with SHIMMER. Then, all the above-described features could only be performed if Bluetooth connection is available for communication between a computer and SHIMMER.

As may be seen in Figure 7, temperature values are presented using a graphical representation. Thus, it is easy to visually identify values outside the normal pattern. These values can lead to sign a range of conditions on female reproductive system (e.g., pregnancy contractions, ovulation period, best fertilization period, etc.). Next, a medical research will carried out with the execution of very important studies to be applied in different kind of gynecology issues, such as, the preterm labor prevention, detection of pregnancy contractions, anticipation and monitoring of the ovulation period (used either as a natural contraception method or, at the opposite, as a estimation of the best fertilization period), effectiveness of some gynecology therapeutics, and supporting the discovery of new possible contraception methods.

VI. Solution Validation

Comfort, usability and, mainly, accuracy were the goals followed in the construction of the intra-vaginal sensor. These targets should be tested and validated in a real environment. Thus, medical team conducted several tests to perform the solution validation.

The biofeedback solution for intra-vaginal temperature monitoring was tested and evaluated in 12 volunteer women. Each woman was monitored for about 60 minutes with temperature readings per second. Simultaneously, women body temperatures under the arm and under the tongue, was measured using a trivial digital thermometer. After analyzing all the temperature data, medical team validated and certified the accuracy of intra-vaginal temperature readings. After concluding the test, each woman was questioned about the possible discomfort caused by the use of the intra-vaginal sensor. None of them shown any issue related to the use of this biosensor.

The sensor was also tested with 8 volunteer women for a longer period on their normal daily life. These tests were preformed in periods of about 2~3 hours. The results were compared to patterns previously defined with traditional thermometers measures in same places above (under the arm and under the tongue). The medical team confirmed the validation of the results.

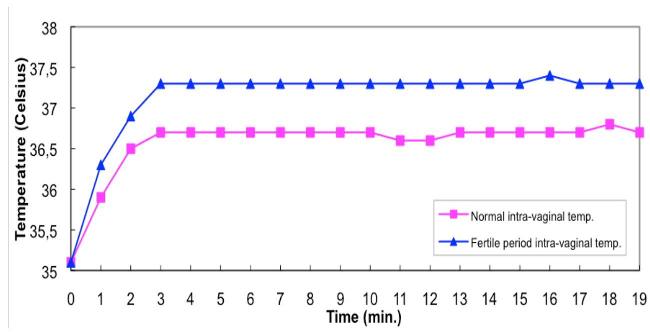

Figure 8. Sample of intra-vaginal temperatures measurements in two different days for the same woman in normal day life.

Figure 8 and Figure 9 present samples of temperature results obtained during tests. In Figure 8 shows temperature values performed by the intra-vaginal sensor for the same woman in tow different days. This graph could be divided in two segments for both curves. First segment, between minute 0 and 2, represents the heating of the sensor to reach ambient temperature (sensor response). The second segment, beyond the 3rd minute, represents the real temperature readings inside vagina. Differences between both temperature readings, beyond the 2nd minute, correspond to the normal intra-vaginal temperature of this woman and her temperature on a fertile period (ovulation period). As expected, intra-vaginal temperature changes according to some female body situations. Monitoring this parameter it could help in medical detection of several situations, such as the preterm labor prevention, detection of pregnancy contractions, anticipation and monitoring of the ovulation period (used either as a natural contraception method or, at the opposite, as a estimation of the best fertilization period), effectiveness of some gynecology therapeutics, and supporting the discovery of new possible contraception methods.

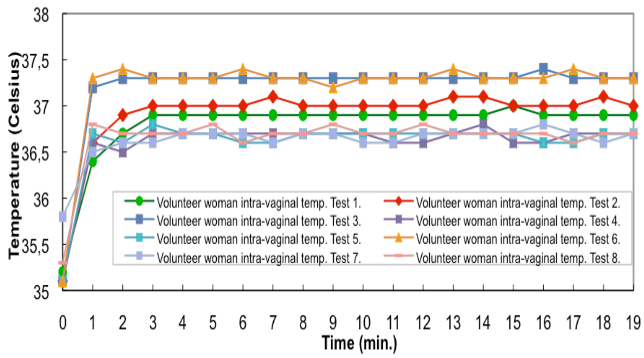

Figure 9. Sample of intra-vaginal temperature measurements for 8 volunteer women.

Figure 9 presents a sample with results of eight tests performed in eight of the twelve volunteers women evaluated. In this graph, the two above-mentioned segments could also be distinguished. From 0 to 2nd minute, it is the response of the sensor and beyond the 3rd minute (after its stabilization), it represents the real temperature values inside women vagina. As may be seen, beyond 3rd minute, differences between both curves means (and confirm) that each woman have her own intra-vaginal temperature. By this reason, individual patterns may have to be established for each woman.

These results represent a great success and encourage medical team for more patients' data collection, using this new biosensor sensor, trying to establish patterns of intra-vaginal temperature behavior. Further, these patterns will be used to understand the relationship between intra-vaginal temperature variations and some reproductive system behaviors, as well as the comparison between patterns and new data collections.

VII. Conclusion and Future Work

The control of women body temperature may help on detection of some symptomatic situations. The environment temperature could influence the skin temperature. This paper introduced a new way to collect women's temperature by the creation of a new biosensor. This biosensor is placed inside women's cervix and collects their core-body temperature. The biosensor can operate in a long-term way, once it has a memory card to store the collected data. The construction of a application software to operate the new biosensor and analyzing the collected data was also described in this paper. The communication mechanisms between the application and the biosensor were also presented. The system was tested, evaluated, and validated by a medical team with a set of 12 volunteer women. The accuracy of the results was also confirmed. Next, medical team will conduct several studies with this system trying to recognize some phenomena related with reproductive system behavior. These studies may contribute for the preterm labor prevention, detection of pregnancy contractions, anticipation and monitoring of the ovulation period, effectiveness of some gynecology therapeutics, and supporting the discovery of new possible contraception methods.

The creation of a miniaturized intra-body biosensor that can be placed inside female cervix, as a hole, instead of placing only the thermistor, may be considered for further developments.

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