MY BABY – SYSTEM REQUIREMENTS

Aleksandra Stojnev Ilić[1]*,
Miloš Ilić[2],
Petar Spalević[3],
Predrag Lekić[2]

[1]Faculty of Electronic Engineering,
University of Niš,
Niš, Serbia

[2]Faculty of Technical Science,
University of Priština,
Kosovska Mitrovica, Serbia

[3]Singidunum University,
Belgrade, Serbia

Abstract:
In modern era, new parents rely on technology to guide them through the development of their babies. In order to create software product that will be useful both for parents and for the community, it is necessary to address all the requirements of such a system. In this paper we define a list of requirements related to system infrastructure, privacy protection, user interface and data collection that will enable us to create a platform that will utilize young parent's willingness to log and share data, while being useful for parents in their everyday struggles. In that manner, we will be able to specify a distributed system that can be used to extract non trivial knowledge related to baby development and based on real world data.

Keywords:
baby development tracking, requirements engineering, data science, machine learning.

INTRODUCTION

One of the most significant challenges for young parents nowadays is baby care. In the era of sensors and actuators, era of information, people are relaying on technology to keep them and their babies safe. Different infant monitoring systems are available on the market. However, these systems just provide information about current situation in close environment. In order to maximize the use of technology and all the advances it can bring, it is necessary to develop a system that will monitor baby's behavior, but also record it so as to learn from it, or use it for extracting non-trivial knowledge. Such system is beneficial both for parents and for the community. Parents will allow the system to collect the data so as to receive valuable information, generate different plots and graphs and so on. Community can benefit from this data as it can be used to train different models and make informed assumptions based on identified correlations in the data itself. However, it is not a trivial task to draw on any systematic research about the requirements of aforementioned system. The specific objective of this study was to identify different possibilities of a system named My Baby intended for use for baby development tracking, and

Correspondence:
Aleksandra Stojnev Ilić

e-mail:
aleksandra.stojnev@elfak.ni.ac.rs

DOI: 10.15308/Sinteza-2020-167-172

create a list of basic requirements for it. In that manner, it will be possible to identify most of the challenges that might arise during the detailed architectural planning of a baby monitoring system.

The system design is dependent on different data input, so it is necessary to define all groups of data sources in order to properly define requirements related to data management and processing. It is important to take into account different data sources, including automatic ones such as different sensors that provide trivial information without any processing, data sources that require the system to perform some kind of processing so as to extract non-trivial data such as camera input, and manual data inputs that require users to provide data using system user interface. Furthermore, in the early stage of the development, it is important to define high-level functional and technical requirements that will define the general system behavior. In this paper we give an overview of available data sources that can be useful for baby monitoring, and we create a list of functional and high-level technical requirements for My Baby system thus creating a testing grounds for further development of the system.

The remaining part of the paper proceeds as follows: First section gives a brief literature overview. Second section describes different data sources significant for the topic. Third section gives an overview of the identified functional and technical requirements. Fourth section concludes the paper.

1. LITERATURE REVIEW

In one of the research authors proposed system that had many features such as: displaying live video and audio, recording audio and playing it to the baby, measuring the room temperature and humidity, supporting Arabic language, determine if the baby is awake or sleep, and the most important characteristic is the ability to listen the baby noise, which is the cry detection feature [1]. Proposed system is tested and compared with the current system and in this way its effectiveness and functionality is proved. Proposed system was consisted of one of the famous microcontrollers, which is Raspberry Pi connected with some objects and devices. This system in comparison with the earlier ones can support seven different features on one system and all of the required properties. Nevertheless, one of the shortcomings noted by the authors is the fact that proposed system does not support the heartbeat-measuring feature. Moreover, the system can send notifications to the parents in some abnormal cases such as high temperature and baby crying.

In research presented in [2] authors described a real-time infant monitoring system for tough hearing parents by using mobile devices based on Android operating systems, which has sensors such as finger heartbeat, body temperature, humidity and sound detection. In particular, this system is designed to monitor physiological information obtained from children and then produces alarms in case of abnormal situations. The implementation of this system depends on one of the Arduino boards which is the Leonardo board. This device is used to collect and sense information using the connected sensors and then create an appropriate alarm, based on this data. Smartwatches and smartphones based on Android operating system were used to report alarms to the parent. From the implementation results, the data collected were observed and sensed by the appropriate sensors which also contain any abnormal conditions and finally the alarms were notified.

Internet of Things-based Baby Monitoring System (IoT-BBMS) is proposed as an efficient and low-cost IoT-based system for monitoring in real time [3]. Authors in this research also proposed a new algorithm for system that plays a key role in providing better baby care while parents are away. In the designed system, Node Micro-Controller Unit (NodeMCU) controller board is exploited to gather the data read by the sensors and uploaded via wi-fi to the AdaFruit MQTT server. The proposed system exploits sensors to monitor the baby's vital parameters, such as ambient temperature, moisture, and crying. A prototype of the proposed baby cradle has been designed using Nx Siemens software, and a red meranti wood is used as the material for the cradle. The system architecture consists of a baby cradle that will automatically swing using a motor when the baby cries. Parents can also monitor their babies' condition through an external web camera and switch on the lullaby toy located on the baby cradle remotely via the MQTT server to entertain the baby. The proposed system prototype is fabricated and tested to prove its effectiveness in terms of cost and simplicity and to ensure safe operation to enable the baby-parenting anywhere and anytime through the network. Created baby monitoring system is proven to work effectively in monitoring the baby's situation and surrounding conditions according to the prototype.

In [4], Kaur and Jasuja proposed a system that can monitor the pulse rate and body temperature of the person. Dedicated sensors are placed along with Raspberry Pi and IoT to monitor the health condition and store the obtained data to Bluemix cloud. The data stored are sent to a doctor for health analysis and to detect abnormalities.

The KG011 sensor is used to measure the heart rate, and the DS18B20 sensor is used to measure the temperature. Then, the readings are shown in the IBM Watson IoT Platform in graph form. The article proposed a good point, which is about using the sensors to send data to the IoT platform. However, this system is unsuitable for infants, because their bodies' immune system is weaker than that of adults. This wearable system might emit some radiation that could harm the infants and cause some side effects.

This system presented in [5] is helpful for busy parents to ensure care and safety of their babies with use of advanced technology. Implemented work going to detect baby's crying sound, motion as well as live streaming of baby position in cradle. The live streaming of babies position and activities are displayed on display unit which helps parents to have continuous baby monitoring. The implemented work deals with design and development of a baby cradle using Raspberry Pi B+ as control unit. The different sensors like rain drop sensor, condenser MIC and camera are used to assist baby monitoring and are interfaced with the Raspberry Pi B+. The baby sound like crying is detected by condenser MIC. Live streaming is done by the pi camera. Baby's urine is detected by wet sensor and SMS will be sent to parents. The result obtained from the designed work shows the easier and convenient way of baby monitoring for busy parents.

Authors in [6] presented a baby monitoring system based on GSM network. This system monitor's body's health parameters like temperature, moisture, pulse rate and movement and deliver these measured parameters on the parent's mobile using GSM network. System presented in [7] includes reminder system as important feature in baby monitoring activity. It conveys measurements of various parameters to the parents with an alarm triggering to initiate proper actions. Using this feature, parents or caretakers can set reminder about feeding time and vaccination date.

2. DATA SOURCES

As for any other data processing systems, a system for baby tracking and monitoring is relying on the input data to produce output. That output can be as trivial as graphics charts of the given input, but can also include results produced by different machine learning techniques along with raised alarms and actions. Complexity of the system is correlated to the complexity of the methods used for analysis and their requirements related to the input data. Input data can be data obtained from traditional baby monitoring systems, different environmental sensors and medical sensors that are used to track specific conditions, smart devices for babies such as smart cribs, data provided by parents or caregivers, historical data and common knowledge data [8].

Most commonly used baby monitors are traditional audio and video monitors. Audio monitor allows parents to hear noise even if they are not in the room. Video monitor sends a video from a camera positioned in the baby's room. These monitors can be replaced with two phones or tablets and appropriate mobile app. However, these types of monitors are used when parent is observing baby's behavior, and are generally not used as a data source for a system that is tracking a baby. Automatized and semi-automatized systems for baby monitoring and tracking are relaying on different sensors that not necessarily produce visible or auditable results, but results that can be easily processed. These sensors can be different: wearable and medical sensors, environmental sensors and movement detectors, and smart sensors that can be adapted to detect specific mimics or behaviors.

Medical sensors enable constant health monitoring for infants. They are often embedded to baby's clothes so as to minimize the discomfort they are causing. They can include fully-integrated sensors for measuring electrocardiography (ECG), temperature, respiration and humidity (excess sweat detectors), pulse oximetry, grip strength, etc. Different papers present novel materials to use for manufacturing the sensors and wearables that include them, such as conductive textile wires [9]. However, some of these sensors are invasive, and are not to be used in normal circumstances: if there is not a medical necessity to monitor baby's medical parameters, same is often not recommended. This is due to sensors that must be attached to baby's body and can cause discomfort. Many of them can be manufactured as a part of baby's clothes, but that can complicate washing the clothes. Since the main idea with this system is to make it easier for parents, it makes no sense to introduce unnecessary sensors that can complicate everyday life and actions. However, if the infant requires continuous health status monitoring, system that processes data from sensors can be used as a clinical tool applied in constant monitoring of physiological parameters and transmit the information to clinicians or parents. In this case, wearable sensors for infants can be a life-saving technology.

Environmental sensors on the other hand do not cause any discomfort for an infant or parents, can be placed near the baby and can be used to monitor not

only the infant itself but also the environment. These sensors include but are not limited to temperature, humidity, weather, CO_2 levels, noise detectors, and light sensors. This type of sensors can be used to control the air-condition devices, to inform parents if something might be causing a discomfort for their baby, etc. However, similar sensors can be used to detect different problems with infant's health. For example, through detecting the variation in the exhaled CO_2 concentration using CO_2 sensors placed in the crib around an infant, system can be able to detect if there is anything unusual with the infant's respiration. Sensors that monitor the baby can be extremely useful in preventing sudden infant death syndrome (SIDS). Although the main cause for this syndrome is not known, there are many studies that link this syndrome with problems in the ability of the baby to arouse from sleep, so if the sensors are able to detect low levels of oxygen or a possible buildup of carbon dioxide in the blood, the system can alarm the parents. When babies sleep face down, they may rebreathe exhaled carbon dioxide, which can also be a use case for a baby monitoring system [10]. Another benefit from environmental sensors is retrieved knowledge: the historical data from environmental sensors can be used to track some problems down to the root and to link different states with the environmental changes. For example, trivial noise detectors can show the cause of baby's insomnia. Non-trivial analysis can extract useful knowledge that can relate some problems to the environmental factors. Given the fact that the system will have access to dataset for different infants and their environment, as well as the context provided by parents, the same can be used to extract different correlations and patterns which are impossible to infer without constant and thorough monitoring of different parameters. This will be beneficial not only for parents, but also for the community and medical sciences in general.

Another type of sensors that can be beneficial for infant monitoring system are different motion sensors that can detect movements of a baby. This can be used for trivial use cases as detecting if a baby is awake, but also for a very complicated analysis related to infant's posture and movements. Different types of sensors can be used for this purpose: camera can take a video of an infant that can be processed to detect the movements, cradle can be equipped with various movement sensors, or they can also be developed as wearables. Video input can be valuable source of information, but in order to extract it, it is necessary to conduct processing of a video input. For example, using eulerian magnification, the system can amplify small infant movements by comparing pixel color differences between subsequent frames and therefore detect basic actions such as breathing [11]. Using pose estimators, system can learn baby's behavior depending on different environmental factors, or even correlate infant mood with detected events. At last, there are smart sensors that can act as actuators, and adapt themselves and the environment based on the readings. These sensors are not of utmost importance when used as a part of an intelligent system for baby monitoring.

Along with the sensors, very important parts of the input data are the data provided by parents via different logging techniques and historical and common knowledge data. Logged data can contain information related to baby's mood, weaning habits, accoutered problems, etc. Also they can include environmental information, pediatrician advices, parents' observations. These logs might seem worthless in the moment of the input, but can be used in different machine learning analysis as a missing data, because they often provide a context for different events. Additionally, logs are the most suitable way of providing information about solids given to a baby. System for monitoring must be designed so to encourage users to log as much information as possible, to ensure a good training set for future knowledge extraction. Furthermore, historical data for monitored infant or other infants that might be of importance along with the data that represents common knowledge should be taken into account when developing machine learning models and knowledge bases.

3. SYSTEM REQUIREMENTS

System requirements related to My Baby platform can be tackled from different points of view. In early stage of a development, it is from utmost importance to firstly define functional requirements that should be implemented. Secondly, technical requirements should be listed. Functional requirements should list all the general functionalities the system should have, while technical ones define the properties of the platforms that can be used for implementation of such a system.

First of all, the system must be scalable and adaptive: it should work with all the provided sensors, and it must be able to support multiple users, providing each one of them with the privacy protection on the level that is requested. Different users will share different amount of data with others, and the system must be designed so to fulfill privacy requests for each user. List of the available functionalities per users is dependent on the available data sources.

One important subset of functional requirements for baby tracker systems are requirements related to infant's nutrition. From day one, system can provide information about breastfeeding or amount of fluids for formula-fed babies based on common knowledge bases and healthcare provider recommendations. Furthermore, as parents start weaning, the system should be able to suggest new solids for baby to try, and different recipes for healthy meals. The key role in this functionality is up to parents, as they must provide all information about already introduced solids, possible allergies, intolerances, etc. Based on similar groups of groceries, system should be able to suggest new solids, or provide parents with groceries lists and recipes. Another subset of this type of requirements includes the ones related to environment adjustments. System should be able to track the environmental parameters from available sensors and, given the thresholds, alarm the parents or automatically use actuators so as to regulate the problematic features. For example, if the temperature sensor is available, and it is detected that it is too hot, system should either activate air condition or alarm the parents, depending on the available components. Another useful feature of our baby monitoring and tracking system is discomfort detection. It should alarm the parents if the baby is experiencing any discomfort. If there is a video input of a baby sleeping in a cradle, using different techniques for image recognition, it is possible to detect for example if an infant is covered with a blanket. Parents should be able to select different events that can trigger an alarm or actions. If an infant requires special medical care, and the system has all the required data sources, the healthcare providers should define different alarms and statuses in the system that are tailored to current condition. Caregivers often need to leave the room where the infant is located, and many of them prefer audio or video streaming features. Although this is something that basic traditional monitoring systems provide, a complex one should have it too. Another important part of the systems are visualizations for parents: different graphs that track measurements such as weight and height or amount of food taken, status of different alarms and parameters, readings from different sensors, and possible recommendations. These graphs can be also useful for pediatrician that is monitoring baby development – parents can show them the information in the system during the monthly check-ups, for identification of possible problems. Furthermore, the system should inform the users if some of the input data sources are not working properly. It is not uncommon for sensors to fail, but the parents must be informed if the system is missing the needed data sources. This is very important if the system is used to trach critical medical conditions.

Baby monitoring system should be flexible regarding the input data sources. Different infants and parents have different needs and require different measurements and logging activities. System should be able to work with different sets of input data sources, although it is possible to define minimal requirements regarding input data for each of available functionalities. For example, if there is a cry detection capability, users must provide the input from which the system can be able to detect and recognize noise. Furthermore, if parents choose to rely on the system related to baby's weaning, they should log every introduced grocery as well as baby's reactions to it. For each introduced functionality, data input requirements must be defined and checked in a runtime.

Technical requirements are dependent on the design solution. They include both internal interface constraints between the elements of the system and implementation details for each of the components. In [12] we presented architecture for baby tracking and monitoring system named My Baby. An overview of this architecture is given in Fig. 1. This architecture implies most of the technical requirements, as well as the communications between different modules.

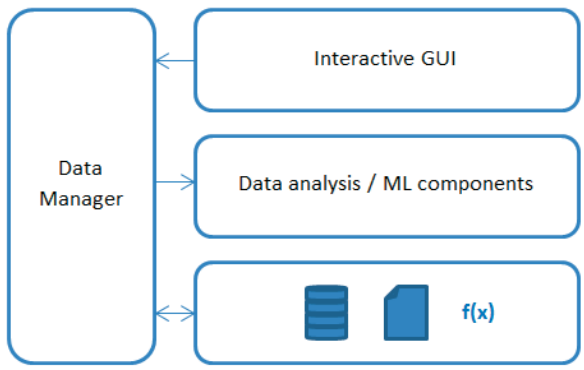

Fig. 1. My baby – system architecture.

Defined modules include interactive GUI, data manager, data analysis and machine learning module, database and a set of rules and models representing a common knowledge. Data manager should support different data sources listed in section II. Data from these sources should be stored and processed locally, but also, after applying various anonymization techniques, can be shared with other users of the system. This will create a perfect ground for a development of a common knowledge basis because the parents will log data for their own needs, while contributing to the community. In order to ensure data protection, module must include components for safe data storage and sharing.

This module should be implemented in a distributed manner: one part operates on the edge managing user data, while another part is responsible for updating and retrieving global resources. Graphical interface of the system must be adapted to different users, therefore it must be configurable. A mobile app that provides an interface to the system should be developed to make the system more accessible to parents. It is important to allow users to input data easily, and to interact with the system: define different alerts, rules or share data. Another important module of the system is module that encapsulates knowledge bases, historical data and extracted models. Depending on the number of users, this data can be managed using either traditional databases or Big Data solutions. There should be a way to provide the system with different rules and to represent knowledge obtained from pediatricians and literature, so this module is connected to the graphic user interface via data manager module. Module for data analysis and machine learning is distributed: it must be able to run locally to provide personal assistance for infants, but also it must be able to extract knowledge from the data acquired from different users.

Furthermore, entire system should follow cloud-edge paradigm: data that is important for individual users should be stored locally, while processed data and knowledge representations and models should be stored in a cloud and be easily accessible. In that manner, it would be possible to optimize data driven capabilities of the system by bringing data collection, processing and alerting as close to the end user as possible. This can eliminate latency, leading to faster response times, which makes the collected data more relevant, useful and actionable.

4. CONCLUSION

The aim of the presented research was to examine the possibilities and basic requirements for a system aimed for monitoring and tracking the development of infants. We created an overview of different groups of available data sources that can be used as an input for the system, and create a list of basic requirements that must be met so as to create a system that will be useful both for parents and for community. The proposed system, called My Baby, complies with the standards of cloud-edge architectural paradigm. The most important benefits of this paradigm for baby tracking and monitoring system are ability to increase network performance by reducing latency, reduced amount of data at risk regarding privacy issues, scalability and flexibility regarding number of users and connected devices, powerful analytics and machine learning programs. The present study lays the groundwork for further planning and implementation of My Baby system. Our future work will include detailed architectural requirements and plans for system development, as well as the actual implementation.

REFERENCES

[1] I. Dina, H. Mohammed, A. Sadaf, and M. Sajid, “Raspberry Pi-based smart infant monitoring system,” International Journal of Engineering Research and Technology, vol. 12, no. 10, pp. 1723-1729, 2019.

[2] F. Aktas, E. Kavus, and Y. Kavus, “A real-time infant health monitoring system for hard of hearing parents by using android-based mobil devices,” Journal of Electrical and Electronics Engineering. vol. 17, no. 1, pp. 3107-3112, 2017.

[3] W. A. Jabbar, H. K. Shang, S. N. Hamid, A. A. Almohammedi, R. M. Ramli, and M. A. Ali, “IoT-BBMS: Internet of things-based baby monitoring system for smart cradle,” IEEE Access, vol. 7, pp. 93791-93805, 2019.

[4] A. Kaur and A. Jasuja, “Health monitoring based on IoT using Raspberry PI,” in Proc. Int. Conf. Comput., Commun. Autom. (ICCCA), pp. 1335-1340, 2017.

[5] A.R.Telepatil, P.P.Patil, S.S.Yajare, and S.R.Jadhav, “Intelligent baby monitoring system,” International Journal of Research in Advent Technology, vol. 7, no. 6, pp. 191-194, 2019.

[6] S. P. Patil and M. R. Mhetre, "Intelligent baby monitoring system", ITSI Transactions on Electrical and Electronics Engineering, vol. 2, Issue 1, pp.11-16, 2014.

[7] S. Shreya Pai, S. Cynthia Pereira, T. Nicole, A. Ushadevi “Advanced baby monitor,” International Journal of Internet of Things, pp 51-55, 2017.

[8] Z. Zhu, T. Liu, G. Li, T. Li, and Y. Inoue, “Wearable sensor systems for Infants,” Sensors, vol.15, no. 2, pp. 3721–3749, 2015.

[9] W. Chen, S. Dols, S.B. Oetomo, and L. Feijs, “Monitoring body temperature of newborn infants at neonatal intensive care units using wearable Sensors”. In Proceedings of the Fifth International Conference on Body Area Networks, Corfu Island, Greece, pp. 188–194, 10–12 September 2010;

[10] S. Bouwstra, W. Chen, L. Feijs, and S.B. Oetomo, “Smart jacket design for neonatal monitoring with wearable sensors”. IEEE Body Sens. Netw. vol. 40, pp. 162-167, 2009.

[11] D. Yogita, and G. D. Sachin, “Baby monitoring system using image processing and IoT,” International Journal of Engineering and Advanced Technology (IJEAT), vol. 8, Issue 6, pp. 4961-4964, 2019.

[12] S.I. Aleksandra, I. Milos, S. Petar., A.H. Shanta A.E.S, “My baby – system proposal”, In: Zdravković, M., Konjović, Z., Trajanović, M. (Eds.) ICIST 2020 Proceedings vol.2, pp.244-249, 2020.