Bilkent University

Department of Computer Engineering

Senior Design Project

Project Name: VANNY

Project Specifications Report

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1. Introduction

Babies and toddlers are the main focus, care, and concern of all parents. From providing the best food and medical care to paying babysitters to setting up a nanny cam, parents will stop at nothing to make sure their babies and toddlers are healthy and safe. Nanny cams specifically play an increasingly important role in helping parents extend their love and care beyond their immediate physical vicinity, allowing the parents to have a reliable and transparent tool to watch their loved babies and toddlers. The common available nanny cams, however, can be optimised to push this reliability and transparency farther if the newest and most capable technological tools were integrated in said systems. Furthermore, by making these systems more intelligent and able to communicate with the parents the current nanny cam systems can be extended and transformed into an additional caring eye that is always present in the babies and toddlers bedrooms or playrooms.

After conducting a market research we observed that most of the current nanny cam systems don't utilise some very useful Artificial Intelligence and Machine Learning algorithms efficiently. Alfred Home Security Camera, for example, is the most popular similar system on Apple's AppStore with over 40 million users, detects intruders by detecting "any movement", with no other AI or ML capabilities utilised. It can also live stream, see in low-light environments, and act as walkie talkie, among other common features in security cams[1]. Another example "Annie Baby Monitor" acts as a basic nanny cam with motion detection and the ability to play lullabies[2]. Similarly other examples of such systems have motion detection with other AI capabilities like detecting noise and crying and notifying the parent that the toddler is awake[3][4][5]. The most capable similar system is "Mi Home Security Camera". The aforementioned system is a general security camera system. Moreover, it has an angle of 130 degrees, has infrared and night vision scopes, and acts as a two-way voice communication system. In terms of AI capabilities, it has a zoning functionality that makes the system more sensitive to movements in these zones and can detect family members in the camera's range, using Mi Bands or iPhones and turn off when they are in range[6]. Finally, other specialised systems that focus strictly on a specific problem exist. "Angel Eyes", as an example, watches the baby while sleeping in the crib. The system uses a camera to watch the baby and detects any issues, like objects in the crib, or if the baby is in an unsafe position, and uses sensors to monitor humidity and temperature in the room[7]. Another system detects the hunger of the baby using some cues[8].

A more optimised system will act as a general purpose more capable nanny cam that fits somewhere between "Mi Home Security Camera" and "Angel Eyes", and more capable than

the other aforementioned nanny cams by utilising the capabilities of AI and ML and focus on the toddler in their rooms. Ideally, this system will transform nanny cams by pushing them to the limits of the possible capabilities.
This document describes the specifications of a system that optimises and transforms these systems into a virtual babysitter. Note that the age group of children that are the target of the system is 0 to 5-year-old, the document will refer to this age group as toddlers.

1.1 Description

VANNY (Virtual nANNY) is a Machine Learning, AI, and IoT software used as a virtual babysitter. The system will be a wide-range camera, with night vision, fixed in the corner of the toddler's room, along with a microphone and a speaker, the system will connect to a phone application to communicate with the parents. The system will watch a toddler 24/7 in their rooms in order to assure the parents that their toddler is safe and sound. The camera will monitor the toddlers and their surroundings, detecting any possible danger, including, but not limited to, fire and smoke, sharp objects, foreign moving objects, other toddlers, strangers, and loud noises. Additionally, the system will watch the toddlers themselves in case they fall or cry. Once crying is detected the speakers can be used to play a lullaby that is pre-recorded or fetched from the internet. Finally, the system will analyse the toddlers' daytime movement's patterns, amount, and patterns; the toddlers' sleep's depth, and durations; and the toddlers' crying loudness, duration, and times. Parents will use the mobile application to be notified in case any danger was detected, or if the toddler hurt herself or cries for a certain time or loudly.

The mobile phone will act as a messenger between the system and the parents. Through it parents can watch their toddlers live, receive notifications and reports after the analysis. The analysis' aim is, solely, to help observe any unusual patterns in the toddlers' movement, sleep or crying, not to provide medical advice. For example an unusually low amount of movement or long crying in the night can provide a hint to the parent's regarding the toddlers' health or unomforts, i.e growing teeth, bad room temperature, etc.

When all of these components are put together the system will act as a virtual babysitter that helps parents extend their care beyond their physical vicinity, and be at ease when they are not around. Moreover, the system will be completely local, making it more secure and avoiding privacy fears that can turn the system to a source of concern instead of comfort.

The innovation type of this system would be “Product Performance” since it focuses on the value, features, and quality of the service, and it attempts to outperform competitors. One important issue regarding this type of innovation is that it is usually easy to copy, and perhaps, be outperformed by other, larger competitors. Additionally, since the needs and features are pre-existing and already realised by the customers but are also adaptive and will continuously improve our innovation is a mix of sustaining and incremental innovation.

1.2 Constraints

Implementation Constraints:
The system will follow a client-server architecture, with the main system as the server and the phone application as the client.

- Git will be used as the version control system in order to synchronise the team’s work and work systematically via the branches for each feature.
- GitHub will be used as the repository hosting service and GitHub issues will ease the work distribution among the team members. Using issues and merge requests also enables the team to review the overall work done by the team members, and discusses any possible issues.
- Throughout the project, Google Docs will be used in order to prepare the reports together with the team.
- Android Studio will be used together with Java as the programming language in the client side of the application.
- Python will be used on the server side of the system.
- The Machine Learning libraries that will be used are TensorFlow and TensorFlow Lite for the process of model making.
- OpenCV will be used as the general visual processing library.

Technological Constraints:

- A Raspberry Pi device is needed to be used as the server and to run the application.
- A camera device, with night vision, is needed to watch the babies and toddlers in real time.
- A speaker device is needed to convey the voice of the mother or a lullaby to the toddlers.
- A microphone device is needed to receive the voice of the toddlers and also the environment.

Economic Constraints:

- Free software tools and libraries will be used in the implementation of the application.

- Users will need to buy the hardware components only and install the software to use the system.
- VANNY's price should not exceed the average price of a nanny cam system by a large amount, to make it affordable for families.
- All updates and optimizations will be obtained for free.

Environmental Constraints:

- Since the system runs continuously power-efficiency is a concern that will be addressed in order to reduce electricity consumption and make it more environment-friendly.

Political Constraints:

- The application will be available for personal use only with the consent of the family avoiding any possible political issues.
- Any expansions of the system into public areas could face political backlash.

Ethical Constraints:

- The recorded data will not be shared by any third party organisation or individuals. Only the parents of the toddlers will have access to the stored data.

Health and Safety Constraints:

- The camera, microphone, and speaker devices need to be fixed and far from the toddler to avoid them falling on the toddlers or harming them in case of electric shortages or similar issues.

Sustainability Constraints:

- The trained models will be improved over time to be more efficient and optimised.
- The product can be improved according to the user feedback in terms of the accuracy of the detection or any possible issues.
- The quality of the hardware components will be assured and periodic maintenance will be performed.

Data Constraints:

- The amount of data that can be saved is limited by the local storage that is provided by Raspberry Pi 4 and its SD storage card.

Time Constraints:

- The system needs to detect any issue real-time and therefore should be able to notify parents in a few seconds.

Reliability Constraints:

- The accuracy of the trained model needs to be as high as possible in order to prevent any danger from being detected.
- The system should notify the parents in case no phones are connected or if some components are not functioning properly.

1.3 Professional and Ethical Issues

In order to avoid licence and copyright issues that might be encountered during the development, the open-source libraries will be preferred during the development. Similarly, all software tools that will be used will be free or properly licensed for our usage. All code excerpts copied from the internet or other sources will be referenced properly.

The application will record the babies and toddlers with the parents consent. It will not be used in any public area which might cause some ethical and social issues. The application will run on a local network and only the devices that are authorised with a predefined password will be able to connect to the camera. Therefore, if any kind of security problem occurs in the local network, the data cannot not be obtained by the attackers.

User data will be protected according to the GDPR (General Data Protection Regulation) and KVKK (Kişisel Verilerin Korunması Kanunu) regulations. Any recorded data that is unnecessary for the client and for the performance of the application will not be stored. It is planned to store the highlights and important records with approximately 3 minutes periods will be stored instead of storing the whole record. Moreover, the stored data will be permanently deleted after a period of time such as 3 days unless the user chooses to keep it. Only the parents of the babies and toddlers will have access to the stored data and the live records and that data will not be shared with any third party organisation by any means.

2. Requirements

2.1 Functional Requirements

2.1.2 System Mode Functionalities

- The system must be able to detect a baby or a toddler.
- The system must be able to detect other individuals.
- The system must be able to detect moving objects.
- The system must be able to detect the toddler falling.
- The system must be able to detect open doors and windows.
- The system must be able to detect fire or smoke.
- The system must be able to detect sharp objects.

- The system must be able to detect sources of light.
- The system must be able to detect crying.
- The system must be able to detect loud noises.
- The system must detect and react in real-time.
- The system must have a night vision.
- The system must be able to analyse the movement duration and frequency.
- The system must be able to analyse crying duration, frequency and loudness.
- The system must be able to notify the parents about the status of the toddler.
- The system must be able to notify the parents about any changes in crying or activity patterns.
- The system must be able to analyse the baby or toddler's sleep's depth, movement and durations.
- The system must be able to hold video records of unusual or important events, like detection of unusual or dangerous entities or people.
- The system must be able to play lullabies.

2.1.3 User Mode Functionalities

- Users must be able to watch a live stream of the camera.
- Users must pair their phones securely with the system.
- Users must have access and control of all forms of recorded data.
- Users must have access to all forms of reports generated by the system, including highlights, activity, sleep, and crying analysis.
- Users must be able to turn off the camera when desired.
- Users must be able to choose a lullaby from the internet to be played or to record their own lullabies.

2.2 Non-functional Requirements

- **Security:**

  Since the data used in the application contains sensitive information, it needs to be secure in order to prevent any outside access .
- **Reliability:**

  The application will be to detect unusual activities without any anomalies.

  The application will perform well-being tests to report any partial failures.
- **Effectiveness:**

The system will detect various types of possible dangers and report them to parents within 5 seconds, protecting the toddler continuously.

- **Memory Optimization:**

  Recording of the last 3 days will be saved locally in case the parents need them.

  Recordings that are older than 3 days will not be saved except when unusual activity or issues are detected. The recorded moments will be stored for only 7 days to increase the storage efficiency.

- **Privacy:**

  User data will be protected by encryption between the server and the client in the system.

  Recordings will be private with access from any third-party or individuals.

  Users can disable the recording whenever desired.

  Users can delete any form of data saved.

- **Reporting:**

  Any suspicious activity will be reported to the user immediately and saved for 7 days.

  Analysis of activity, sleep, and crying will be reported regularly to the parents.

- **Extensibility:**

  For the application to be extensible, its implementation will be modular and systematic. Thus, the application will be compatible with updates and features to be added or removed.

- **Robustness:**

  If a failure of the application occurs, the application will be able to restart automatically and continue from where it failed without losing information.

  The system will perform well-being tests and confirm that all components work and try to resolve any connectivity issues.

- **Usability:**

  The system will require a one-time setup afterwards users can use the system without directly interacting with the server side.

  The UI of the phone application will be designed so it is used by any user regardless of their tech knowledge.

- **Efficiency:**

  The system will be able to watch a frame-per-second rate of at least 10.

  The system detects any issues and reports in real-time therefore the notifications sent to the user should arrive within 5 seconds.

The system will delete full day recordings in 3 days and highlights in 7 days, enabling efficient memory management.

- **Ethical:**

  Parents will be made aware of what the system records and for how long.
  No third-party activity of any kind will have access to the data stored.
  Reports generated will only be shared with parents.
  Encryption and predefined password will be implemented to prevent any undesired access and undermining toddlers' safety or privacy.

3. Discussion

While analysing the requirements and constraints of VANNY the team realised the massive areas of possible expansions. To begin with, the system can be repurposed to monitor other spaces where some individuals are not fully aware or capable of detecting or stopping danger or abuse. This includes, nursery homes, ICU units, and childcare institutions. Furthermore, the system can detect more complicated patterns and behaviour, like hunger and abuse. Finally, some components can be physically merged into one component and be optimised to meet our particular features.

Regarding the innovation type of the system, "Product Performance", the team realises the copy-ability of the features of the system and how it can possibly be outperformed. That is the reason that next phases of the system would need to expand to other fields, be optimised and focus on other innovation types, like "Service", "Brand", and "Process" in order to survive and excel.

All of the mentioned issues would be addressed and considered in the coming phases after the initial delivery as a Senior Project, or during this phase if the time and resources allow.

4. References

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