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Baby Bump: A Monitoring System for Pregnant Mothers and Babies

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***Abstract* - In present days, countries including Sri Lanka have been developing themselves to provide their population with better life expectancy. Health has been an important point while talking about life expectancy. Low health decreases life expectancy, meanwhile, high health increases life expectancy. While talking about health, birth and death are the most important events linked to it. Birth is a point of life to create a living being which would have the ability to live through the future generations and expand it. Without birth, there wouldn't be any beings living on the earth. But these days, people are experiencing problems in giving birth and a healthy pregnancy. Infants die while they are in the womb. Some of the infants are not healthy enough. So, it was better to propose a solution for the pregnant mothers and babies to develop life expectancy of Sri Lanka. The solution is a Mobile Application including a Nutrition Predictor, Medicine Effect Predictor, AI chatbot and Baby status predictor.**

Keywords: infant, fetus, nutrition, ultrasound, drugs, conversations, maternal death, abnormality, malnutrition.

I. INTRODUCTION

Pregnancy is the period when a mother carries a fetus inside her womb until it gets delivered to see the outside world. During the pregnancy time, the mother's belly would enlarge itself to carry the fetus as well as the fetus grows itself using mother's nutrition. So, the mothers must be healthy mentally and physically to protect their own babies. But the situation is reversed these days. Maternal Deaths have been increasing year by year. Pregnancy is a mother's dream period, thinking and imagining how her baby would be. The output of the dream must be worthful because of the expecting period is a bit long (10 months). An unexpected result will be able to change a mother's future. While talking about avoiding infant deaths, another area, which is Infant abnormality must be concerned too. Death is intolerable, but what is more intolerable than death is living with an abnormality. Many problems will arise which the parents have to be tolerable and patient to handle those. A life with extra care seems to be a depressing and stressed life with more carefulness.

So, the Research group has decided to come forward with a solution to make a healthy environment for pregnant mothers and babies. Some problems had to be sorted out to finish the solution. Lack of Health was the main problem for an Unhealthy pregnancy. As mentioned as health, it considers both Physical and Mental. Both must be taken care of to ensure the baby's health. If not, consequences must be faced at the end. Unsuitable medications and forgetting medications at the correct time during pregnancy period was another problem. Medications are must as well as had to be taken with the doctor's advice and required time. Lack of healthy communications or contacts to take advice or suggestions on critical situations during pregnancy period was another issue faced by mothers. Questions during pregnancy times must be solved without taking much time. Lack of clearance on their baby's growth was the other issue during pregnancy. Mothers will be curious enough to know about their baby's status and it is a must to let them know to avoid future disappointments. Capturing these four main problems, the group has decided to propose a solution as a Mobile Application using React-Native including a Nutrition Predictor, Drug Effect predictor, AI chatbot and a Baby status predictor.

II. LITERATURE REVIEW

Research conducted on monitoring pregnant mothers and babies are listed below. According to [1], the research highlights the need for individualized nutrition advice for diabetes patients, highlighting the threat of diabetes and the potential impact on patient safety. It also highlights flaws in current methods and calls for more reliable and knowledgeable solutions to support diabetic patients' dietary decisions. In [2], An Online Recommender System for personalized nutrition advice is proposed to promote healthy diets and lifestyle modifications due to noncommunicable

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diseases. Utilizing a validated Food Frequency Questionnaire, the system evaluates users' food consumption and provides personalized nutrition guidance based on preferences, population data, and subject-matter expertise. As mentioned in the Introduction, about the second problem, some studies were identified on the same area. The study [4] refers to A survey of 1,793 pregnant women and mothers of children under five assessed their perceptions of teratogenic risks associated with drug use during pregnancy. Factors like first-time mothers, higher age, higher education, and choosing not to use drugs were associated with higher risk perceptions. However, over 80% of women used drugs during pregnancy, primarily paracetamol, penicillin, and reflux medications. The study emphasizes the importance of healthcare providers using evidence-based information to alleviate anxiety and ensure safe and appropriate treatment.

According to [5], Balancing benefits and risks during pregnancy is crucial due to limited evidence on fetal safety for most drugs. Careful evaluation and categorization are essential for managing prescriptions. Individualized care, informed decision-making, and considering non-drug alternatives are also crucial. Collaborative efforts among healthcare providers ensure optimal outcomes for both mother and baby. According to these studies, there wasn't any research conducted on predicting medicine effects on pregnant mothers. Also, there wasn't an automated mobile application for reminder system to take medicine. When searching previous studies on the 3rd problem, there some researches have been found. According to [7], it shows how Chatbots offer pregnant women an affordable and accessible way to access information and assistance during their pregnancy. They provide personalized guidance based on the mother's needs, enabling informed decisions about health and well-being. Chatbots can promote self-care and improve pregnancy health outcomes by advising on good habits like nutrition and exercise, as well as emotional support to manage anxiety and stress. These benefits contribute to a healthier life and improved pregnancy outcomes.

A study [8] discusses the development of a user-centered natural language processing chatbot system for maternal monitoring, highlighting its growing popularity in maternal healthcare. The authors emphasize the importance of designing personalized, informative, and personalized chatbots that cater to pregnant women's needs. They emphasize the need for accurate information, privacy, and security concerns, as well as remote monitoring for early detection and timely intervention. While analyzing these studies, the difference of this research was understood, that there are studies on implementing an Android Solution of Chatbot for mothers. Continuing searching for the 4th problem, there were some researchers identified. According to [9], A review study analyzed 145 fetal ultrasound image analysis studies using Deep-Learning Algorithms since 2017. The study reveals that current research on DL algorithms for fetal US image analysis lacks coverage of all four parameters needed for accurate analysis.

As a study of analyzing Ultrasound Image was conducted on [2], it focuses on Fetal head circumference (HC) which is one of the significant factors to determine the fetus growth and health. In this paper, a multi-task deep convolutional neural network is proposed for automatic segmentation and estimation of HC ellipse. From these studies, the difference was clearly shown that there wasn't a study conducted to analyze a baby's growth status through Mobile Application. As moving forward, the group decided to make the solutions advanced from these existing studies.

III. METHODOLOGY

The main purpose of this mobile application is to ensure that the mothers are keeping their baby's growth trend and their mental and physical health correctly. So, the group has determined to include above mentioned 4 components. A Nutrition predictor to predict personalized meal plans, an Emotion predictor to monitor the emotions, Medicine reminder and effects predictor to remind to take medicines in time, An AI chatbot to solve mother's questions and Baby status predictor to know the baby's growth stage.

A) Nutrition Predictor and Emotion Detector

This component concerns 3 body measurements which are Hemoglobin Level, Diabetic Level and BMI levels to predict personalized meal plans. The survey that the group conducted was the reason to select these 3 conditions. Blood reports are the only way to retrieve these measurements which are OGTT (Oral Glucose Tolerance Test) and CBC (Complete Blood Count). Using Machine Learning was the only solution to extract the value from the images. Talking about Machine Learning, OCR (Optical Character Recognition) is the main concept used in this component. OCR means extract the text from images into digital format. Dataset of images were needed to train and test the OCR model. The needed dataset was collected from the clinic of the VOG, whose name is mentioned above. Using those images Data labeling was performed to let the model know what text the image includes. Label Studio was used to annotate the images which gave the results in a JSON format. Data preprocessing was finished up to this point. After that, the model was trained using the images and annotated JSON file. Before training, the images of the Blood reports are assigned as inputs and the annotations are assigned as outputs. The model was compiled using Convolutional Neural Networks and trained using 200 epochs as shown in Fig. 1.

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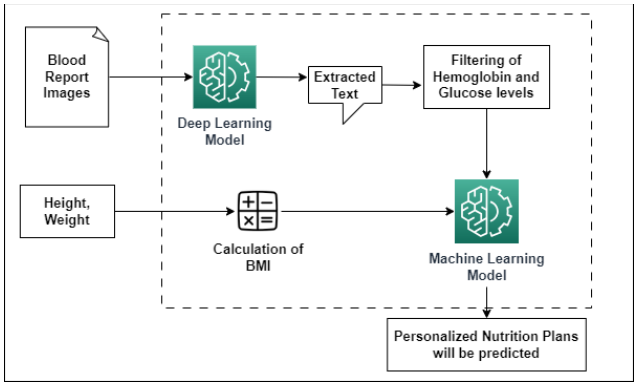

Figure 1: Structure of the Nutrition Predictor

Using the trained model, the testing set of the images were tested and accuracy was calculated comparing with actual and predicted outputs. Finally, the model was converted into .h5 format to host the model using python flask. After converting, the model was hosted in a specific URL to connect it with the React-Native Application. Axios was the package used for the connection. The application gave the ability to capture the image and post the image URL to the model URL using Axios. Then, the GET method was used to retrieve the extracted texts. At this point, the text was extracted with accuracy because the images were printed. But only some of the texts were needed from the images. So, a python array was assigned including the needed text to be extracted. Using the array, prioritized texts were extracted and pushed into another ML model to make nutrition predictions. This model was trained using a dataset which holds Hemoglobin, Glucose, BMI levels and suitable meal plans. The normal levels of the 3 body stats are shown in Table. 1.

TABLE I. NORMAL RANGE OF 3 BODY STATS USED

Body Stats	Range
Hemoglobin	11.0- 16.0
Glucose	72- 125
BMI	18.5- 24.9

Classification algorithms were used to train this model configuring the 3 measurements as inputs and meal plans as the outputs. So, the measurements extracted from the text will be inputted in this model and the final meal plans will appear on the React-native frontend template. As physical health was considered, it was important to take concern about mental health too. Emotions were the only way to understand the mental health of a person. So, Emotion Detection was the only concept that could be used for this part. Images of various emotions were retrieved from Kaggle.com to train and test the model. Using the images, 7 emotions were labelled to find out the most suitable one. Anger, Disgust, Fear, Happy, Neutral, Sad and Surprise. The model was compiled using Convolutional Neural Networks and trained using 450 epochs. The model was tested using the test set of images and gained a higher accuracy. Then the model was saved in .h5 format to host using python flask. After the model was hosted, the URL was used as mentioned earlier in the Application to post the image using Axios. Then, the emotion will be retrieved using the GET method. The results from this model will be passed on to another rule-based system, which will instruct the mothers to do activities according to their emotional status. The process of this model is shown below in Fig. 2.

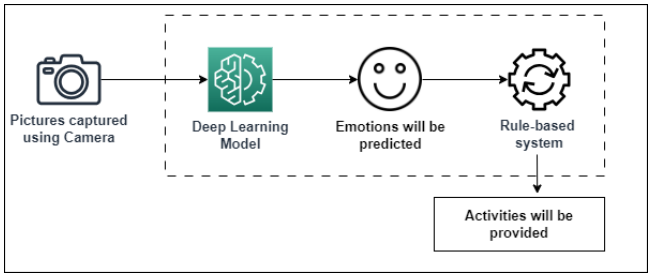

Figure 2: Structure Emotion Monitoring system

B) Drug Effect Predictor

This component was proposed to give concern about the medications during pregnancy times. Before the process, the group ensured the continuity of this component by conducting a survey at De Soysa Maternity hospital, Kynsey Rd, Colombo-08. The survey was evidence that serious cases have been staged at pregnancy time. Mainly, this component was proposed to get correct medicine at correct time. The proposed structure was shown below in Fig. 3.

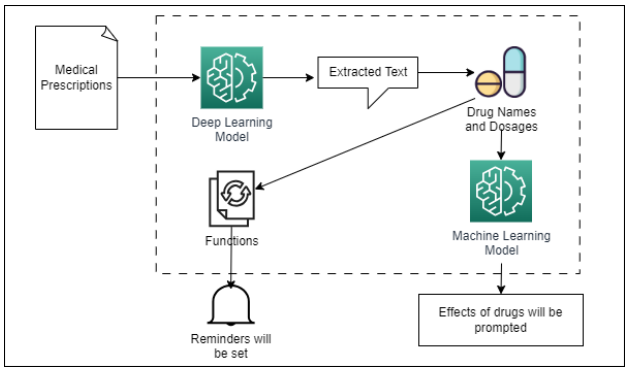

Figure 3: Structure of the Medicine Effect Predictor

Medical Prescriptions was the only way to get the name and dosage of medicine. A dataset of printed and handwritten medical prescription images was retrieved from IEEEDataPort.com. Labelling was performed on those images and then the OCR model was built. The model was compiled using Convolutional Neural Networks and trained using 300 epochs to improve the accuracy. After training the model was tested on the testing image set and saved in .h5 format. Then the model was hosted using Flask and connected with Application using Axios. It will help to post the image and get

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the output from the URL. From the extracted text, medicine names and dosages had to be filtered. In this case, there weren't any public names to filter needed values. So, a concept called NER (Named Entity Recognition) was used to identify medicine names and dosage assigned to them. So, the named entity was assigned as drugs using a corpus named ade_corpus_v2, which contains most of the drug names in the world. Using the corpus, the drug names and dosages were filtered. After that, these outputs were inputted into another model to predict the effects of them. The dataset for that model was retrieved from Kaggle.com. Classification algorithms were used to build the model. Then the model was trained giving drug names as the input and effects on pregnant women as output.

The model was tested and saved in .h5 format. Then it was hosted on a specific URL and connected with the Application as mentioned earlier. The medicine names will be passed, and the effects will appear on the React-native template. As the balance of this component, reminder notification should appear to take the medicine in correct time. So, a function was implemented using JavaScript. The function takes the drug names and dosages as input parameters and then schedules the reminder using "React-native-push-Notification." Library in equal time differences. Using this function, the notification will pop up showing the name and quantity of the drug at the correct time.

C) AI Chatbot

The main purpose of this component is to be an assistant for mothers during emergency times and release them from a depressed situation. So, to create an AI (Artificial Intelligence) chatbot, a dataset of questions and answers of pregnant mothers was created from various sources. The survey, which was conducted at De Soysa Maternity Hospital, Colombo was one of them. For more, web scrapping was performed on some pregnancy care websites. After that, the dataset was modified by including various formats of questions that can be asked. The mentioned task was performed because it was an AI chatbot. Even though the user asks the same question in a different way, the chatbot must prompt the specific answer. Using the dataset, a model was built for training. NLP (Natural Language Processing) was the concept used to analyze text datasets. NLTK (Natural Language Toolkit) was the library used to perform the analyzing tasks. So, using NLTK the questions and answers were converted into small case letters which will be easy for the machine to recognize. Then, the words in a question or an answer were separated using "Word-tokenizer" tool. From those words, stop words have been filtered. Stop words are a set of commonly used words in any language. For example, in English, "the", "is" and "and", would easily qualify as stop words. Then lemmatization was performed to break a word down to its root meaning to identify similarities with other words. Finally, the word dictionary was set to train the model using Convolutional Neural Network with 200 epochs. After training, the model was saved in .h5 format to host it using Python Flask. The structure of the process is displayed below in Fig. 4.

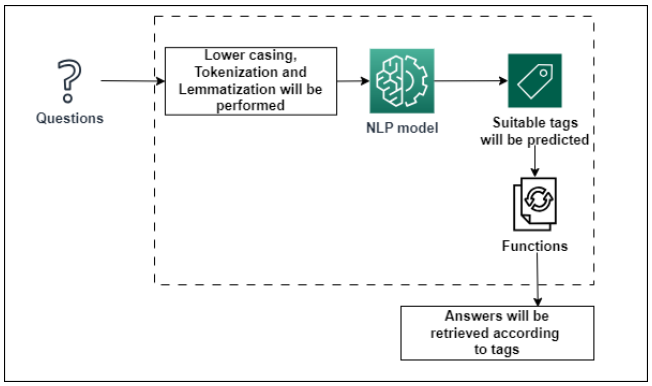

Figure 4: Structure of the AI Chatbot

Then a problem was faced, which is the questions which are going to be inputted to the model must be preprocessed in the same way that the model gone through before training. So, another Python script was created to preprocess the unseen data using some functions. The first one was created to change the input of the user into lower case and to tokenize the words. The second function can check whether the words are in the Vocabulary Matrix and enumerate them. The third one was built to predict the tag of the answer which has been given in the dataset for every pair of questions and answers. The final one was to get the answer for the question using the tag which was predicted in the prior function. Using these functions, the model was hosted into a specific URL using Flask and the URL was passed into the React-Native Application using Axios. This could give the ability to POST the questions and to GET the answers using that URL. Finally, the answers will be provided on the Frontend Template.

D) Baby Status Predictor

This component was proposed to ensure that the mothers know about their baby's status and whether they have any abnormalities during pregnancy period. A dataset of Ultrasound Images was needed to implement this component. The 4 biometrics from the images will help to ensure the baby's growth rate through weeks. Usually, a baby starts to get one of these measurements from the 15th week. So, a dataset was collected from the mothers who have passed their 15th week of pregnancy with the help of the Professor, whose name was mentioned above. Labelling was performed on those images to let the model know what the image holds. The model was compiled using Convolutional Neural Networks

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and trained using 200 epochs assigning the images as the inputs and the annotations as the output. Fig. 5 indicates the structure of this component.

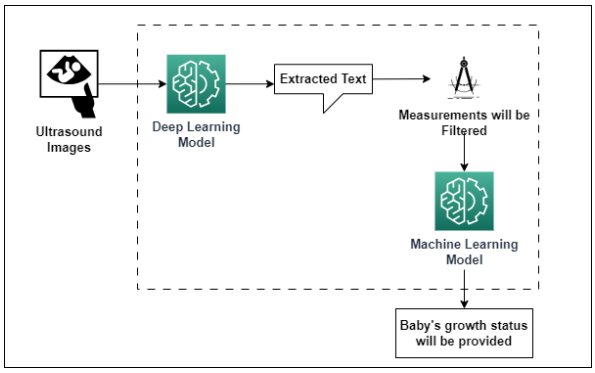

Figure 5: Structure of the Baby status predictor

Using the trained model, images from the testing set were tested to calculate accuracy. After that, the model was saved in .h5 format to host it in a particular URL. The hosting past was done using Python Flask. Then the URL was made connection with the Application using Axios library as mentioned in earlier components. Using the URL, it is possible to POST the images and to GET the extracted text. From the text, needed information had to be filtered out. This task was performed by assigning an array in Python with texts which are important. Using the array, specific texts and values assigned to them were filtered. After being filtered, another model was created to provide feedback variating situations. The dataset for that model was created using values of 5 parameters as input which are HC, AC, BPD, FL, and GA (Gestational Age). The output was reviews according to situations. The model was trained on the dataset using Classification Algorithms. After that, the model was tested on the test set and saved into .h5 format to host it. The URL of the hosted model was made connection with the Application using Axios library to get reviews posting the measurements.

IV. RESULTS

A) Nutrition Predictor

A blood report image was uploaded to the Deep Learning model to extract the important information from the image. The results received from the model is shown in Table. 2.

TABLE II: VALUES EXTRACTED FROM THE BLOOD REPORT

Body Stats	Value
Hemoglobin	10.0
Glucose	83
BMI	20.9

According to these results, HB level is low, Glucose and BMI levels are normal. So, a plan for low HB situation must be predicted by model. These extracted values were passed to nutrition prediction model to predict a personalized meal plan. The predicted results of the Nutrition Prediction model are shown in Table. 3.

TABLE III: PREDICTED RESULTS BY THE MODEL

Input	Output
Hemoglobin: 10.0	HB levels are low. • Breakfast Red rice 1- 1 1/2 cup + vegetables + meat/fish/egg or gram (Kadala) /Black Eyed Beans (Kawpi) with coconut + Kola Kenda 1 cup or Dosa 1-1 ½ • Lunch - Red Rice/ Niwdu 2cups + Vegetables 7 tablespoons + meat/fish/egg • Dinner - Noodles /Pasta 2 cups / 4 Thin Sliced Kurakkan Bread / Dosa 2-3
Glucose: 83	Glucose Levels are normal
BMI: 20.9	BMI Levels are normal

B) Medicine Effect Predictor

A medical prescription image was uploaded to the Deep Learning model to extract important information. The results retrieved from the model is shown in Table. 4.

TABLE IV: EXTRACTED INFORMATION FROM THE PRESCRIPTION

Drug Name	Dosage
Amoxicillin	1 Cap 3X

According to these results, the Effect of Amoxicillin must be predicted from the upcoming model and notifications must be created in equal time differences. Starting Time of the day has been assigned to 8 o'clock. So, 3 notifications must be scheduled for 8, 1 and 6 o'clock. The results from the Effect predictor model are shown below.

TABLE V: RESULTS FROM THE EFFECT PREDICTOR MODEL

Input	Output
Amoxicillin	It does not affect pregnant women. But the side effects are severe stomach pain; or diarrhea, that is watery or bloody (even if it occurs months after your last dose). Common side effects may include nausea, vomiting, diarrhea or rash; Also, your reminder has been scheduled.

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C) AI Chatbot

Some questions which have the same answer were inserted into the NLP model. The same question which was inserted previously was inserted again, but with a spelling mistake in it. The actual questions and answers are shown in Table. 6.

TABLE VI: ACTUAL QUESTIONS AND ANSWERS FROM THE DATASET

Questions	Answers
When should I take a pregnancy test?	You can take a pregnancy test after a missed period or as directed by your doctor.
What is the best time to get a pregnancy test?	You can take a pregnancy test after a missed period or as directed by your doctor.
What is the best time to get a prenancy test?	You can take a pregnancy test after a missed period or as directed by your doctor.

The predicted result from the Model is shown below in Table. 7.

TABLE VII: PREDICTED RESULTS FROM THE CHATBOT

Input	Output
When should I take a pregnancy test?	You can take a pregnancy test after a missed period or as directed by your doctor.
What is the best time to get a pregnancy test?	You can take a pregnancy test after a missed period or as directed by your doctor.
What is the best time to get a prenancy test?	You can take a pregnancy test after a missed period or as directed by your doctor.

D) Baby Status Predictor

A Fetus Ultrasound Image was uploaded to the Deep Learning model to extract important information. The results received from the model are shown in Table. 8.

TABLE VIII: EXTRACTED RESULTS FROM THE DL MODEL

Fetus Biometrics	Value
BPD	94.5mm
HC	337.2mm
AC	342.3mm
FL	74.7mm
GA	38w

According to these results, BPD, AC levels are abnormal and FL, HC levels are normal for Gestational Week 38. These biometric values were added to the Status Predictor model to predict the growth status of the baby. The results predicted from the model are shown in the Table. 9.

TABLE IX: PREDICTED RESULTS FROM THE STATUS PREDICTOR MODEL

Input	Output
BPD: 94.5	There is a possibility for IUGR (microcephaly) on your baby. It is better to get advice from the VOG.
HC: 337.2	HC Levels are normal
AC: 342.3	There is a possibility for IUGR on your baby. Anomaly scan has to be taken and advice from a doctor might be suitable.
FL: 74.7	FL Levels are normal.
GA: 38	-

V. DISCUSSION

Pregnancy is an important event of life. It is a 10-month process of expectation, patience and suffering to get a healthy baby. But maternal deaths and fetus abnormalities have increased in Sri Lanka. Improper Nutrition, Unsafe emotional conditions, Unsuitable medications, Lack of communication and Lack of information about the baby were some of the problems for this situation. As a solution for mentioned problems, the research named “Baby Bump” was proposed.

Baby Bump is a Mobile Application to monitor pregnant mothers and babies in weekly duration. It contains a Nutrition predictor, Drug Effect Predictor, AI Chatbot and Baby Status Predictor. The actual purpose of this research is to decrease the number of maternal deaths and to increase baby’s mental and physical health using these mentioned components. The Nutrition Predictor predicts personalized meal plans according to a mother’s Hemoglobin, Glucose and BMI levels using Blood Reports. The Drug Effect Predictor predicts effects of drugs which the mother intakes using Medical Prescriptions. The AI Chatbot generates answers for the questions mother asks. The Baby Status Predictor predicts the growth stage of the baby using Fetus Ultrasound Images. As desired, the results of the components were satisfiable when comparing. The conducted study will be a headway on caring pregnant mothers and babies in Sri Lanka. Fetus Deaths and malformation are expected to reduce in Future through awareness and studies.

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