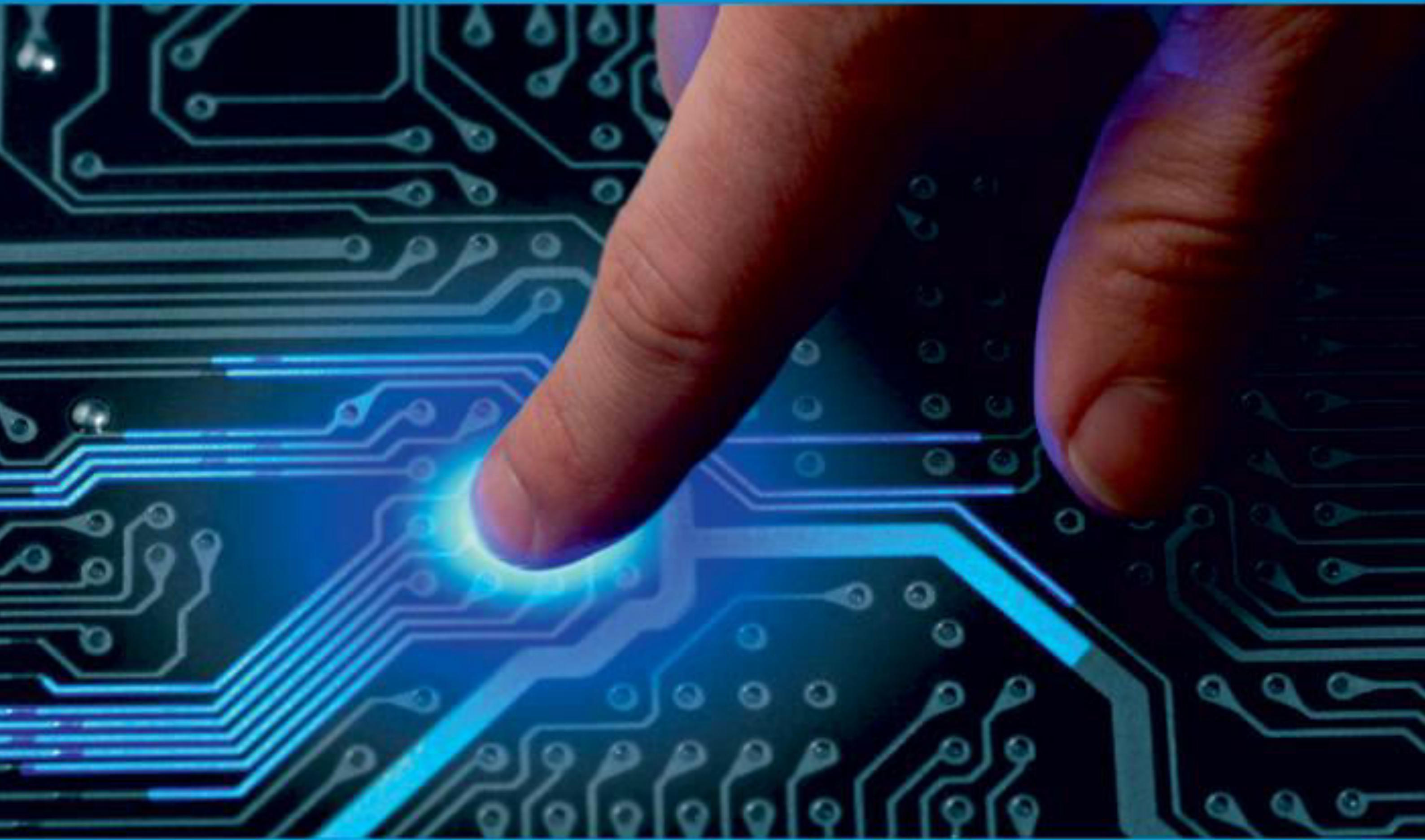
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 9, Issue 9, September 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.542

International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.542

|| Volume 9, Issue 9, September 2021 ||

| DOI: 10.15680/IJIRCCE.2021.0909033 |

Preterm Birth Detection Using Convolutional Neural Networks

Sayali Kandarkar

Sr Software Engineer, JP Morgan Chase & Co, India

ABSTRACT:According to the World Health Organization, approximately 1 million children die each year due to preterm birth complications (1). Many survivors face a lifetime of disability, including learning disabilities and visual and hearing problems. Inequalities in survival rates around the world are stark. In low-income settings, half of the babies born at or below 32 weeks (2 months early) die due to a lack of feasible, cost-effective care, such as warmth, breastfeeding support, and primary care for infections and breathing difficulties. India is the country with the most significant number of preterm births (2). One of the reasons could be the lack of doctors to examine the medical conditions of pregnant women manually. Over 44% of WHO Member States in India reported less than one physician per 1,000 population (3). Hence, developing countries such as India need Artificial Intelligence (AI) systems that would assist the clinicians and eventually require less to no manual intervention to predict such conditions. Several studies have reported that cervical assessment on transvaginal sonography may help predict preterm delivery (4,5). In this paper, a segmentation technique is proposed to predict preterm birth using Convolutional Neural Networks (CNNs). The proposed model is trained on a dataset of 1334 transvaginal ultrasonic 2D images. According to the result, the U-net-based CNN approach achieved more promising results than the current state-of-the-art techniques.

KEYWORDS: Segmentation, Convolutional Neural Networks (CNNs), Spontaneous Preterm Birth (sPTB)

I. INTRODUCTION

Preterm is defined as a condition when babies are born alive before completing 37 weeks of pregnancy. There are sub-categories of preterm birth based on gestational age. There is a dramatic difference in the survival of premature babies depending on where they are born. For example, more than 90% of extremely preterm babies (less than 28 weeks) born in low-income countries die within the first few days of life; yet less than 10% die in high-income settings. Hence, using AI approaches to assist doctors is the need of the hour, especially in low-income countries such as India.

According to a study [6], transvaginal cervical ultrasound is a powerful tool in the risk assessment for spontaneous preterm birth. It is simple to perform, well standardized, and can be quickly learned and performed at the second-trimester anomaly scan. The high negative predictive value avoids unnecessary interventions, such as tocolysis or cerclage in high-risk pregnancies.

Typically, the ultrasonic images are studied by gynecologists during the first and the second trimester of pregnancy. Identifying patterns based on the cervical features merely through the visual inspection of images is a complex task. Due to the complexity involved, up to 40-50% of preterm births are not predicted. Automatic sPTB detection at an early stage would prove to be a great boon to humanity. It could save the lives of many babies who succumb to such conditions.

Over the last couple of years, CNNs have made huge strides in biomedical image segmentation. In this paper, we use U-net architecture to segment the cervix present in the ultrasonic images. We present the usage of cervix features to determine preterm birth. U-net architecture has been proven to return excellent outcomes without requiring high computational power due to the skip connections technique, and we will be employing the same to show the results.

II. LITERATURE SURVEY

Segmentation of ultrasonic images becomes tricky due to various elements like the shape, size, location of organs that vary across patients. Hence, preterm birth detection has been a bit difficult. Let us look at some of the methods used over the years to predict PTB using AI.

In 2019, Prema et al. [7] proposed a classification solution based on logistic regression and the SVM algorithm. The chosen features are age, number of times pregnant, hypertension, obesity, diabetes mellitus (DM and GDM). It shows that the finalized features are crucial in predicting preterm birth. GDM and DM are both implied to be significant preterm birth risks through the study.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.542
|| Volume 9, Issue 9, September 2021 ||
| DOI: 10.15680/IJIRCCE.2021.0909033 |

In 2019, Lee et al. [8] studied 596 women for a classification study to predict PTB. He compares six ML algorithms such as logistic regression, decision tree, artificial neural network, Naive Bayes, random forest, and SVM. The selected features are prior preterm birth, diabetes mellitus, drinker, smoker, hypertension, in vitro fertilization, age, BMI, parity, and cervical length. The model achieves a classification accuracy of 91.14% using an artificial neural network and 91.80% multinominal logistic regression. The study shows that the most critical features used for classification are: hypertension, BMI, cervical length, and age.
In 2020, Rawashdeh et al. [9] utilized EHR data to predict PTB in women with cervical cerclage. Features such as prior preterm, cervical length before and after cerclage, or uterine anomaly and age are selected for the study. Several classifiers such as KNN, random forest, and neural networks are compared. The model obtains an accuracy of 98%.
In 2020, Koivu et al. [10] used a large dataset of almost 16 million observations and proposed experimentation to discover novel risk models that could be utilized in clinical settings. They use three state-of-the-art ML algorithms: logistic regression, artificial neural network, and gradient boosting decision tree. The best performing ML algorithms achieved 0.76 AUC for early stillbirth, 0.63 for late stillbirth, and 0.64 for preterm birth.

III. PROPOSED METHOD

In this section, we will discuss the dataset used and also the preprocessing that has been performed.
We will also talk about the U-net architecture and its advantages.
The dataset consists of 1334 2D transvaginal ultrasonic images downloaded from zenodo.org. The dataset has been divided into 999 training images and 335 testing images. The size of every image is 800 x 540 pixels, with a pixel size ranging from 0.052 to 0.326 mm.
The data was preprocessed using several data augmentation techniques such as adding contrast, noise, brightness to the images. Horizontal and vertical flipping, rotation, and cropping were also used in order to normalize the data and prevent overfitting. In order to perform generalization, the data were divided into training, testing, and validation sets in the ratio of 80:15:5, respectively.
A combination of loss techniques such as binary cross-entropy, dice loss with equal weightage has been used.In order to compare the predicted segmented regions, the segmented masks of the original images were created. All models were trained for 50 epochs. Adam optimizer was used with a learning rate of 10^-4, 1e-4 weight decay.
The architecture employed for the implementation is called U-net. U-net uses an image segmentation technique wherein every pixel of the image is accurately labeled.
U-net works in two parts, as depicted in Figure 1. The initial part incorporates the encoding process where normal convolutions are used, and down-sampling is performed, which shrinks the dimensions of the input images. The second part (decoding) uses transposed convolutions to increase the image scale.
One integral advantage of U-net is the skip connections process, which provides the activations from the initial part of the architecture to the final blocks, and hence the contextual and spatial information is retained without requiring high computational power.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.542
|| Volume 9, Issue 9, September 2021 ||
| DOI: 10.15680/IJIRCCE.2021.0909033 |

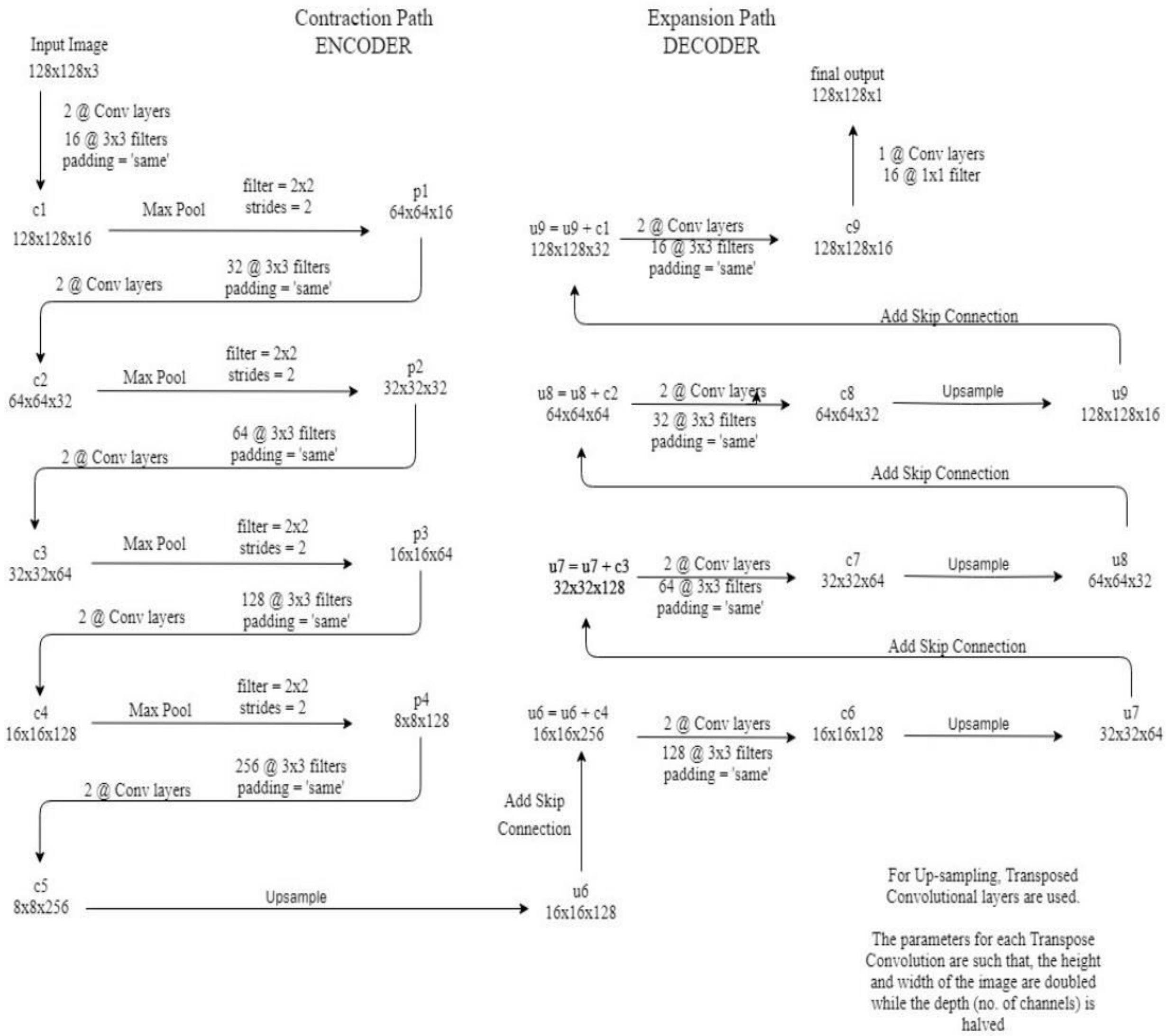


Figure 1. Detailed U-net architecture

IV. RESULTS

This section uses two models for performing cervix segmentation on the transvaginal ultrasonic images: U-net and FCN (Fully Convolutional Network).

U-net performed better than FCN for several reasons.

- It had much additional depth that resulted in better contextual information;
- U-net uses up-sampling, which allows it to retain spatial information as well, which is extremely useful in monitoring the images for later usage;
- U-net uses skip connections which leads to less computational power required as compared to FCN.

Hence, U-net provides better performance than FCN and other state-of-the-art methods. In quantitative comparison, FCN achieved an accuracy of 92%, whereas U-net obtained an accuracy of 97.3%.

Fig.2-5 depict the qualitative analysis results. From Fig.3, we understand that the predicted mask result is very similar to the ground truth. The high resemblance between the original and predicted mask speaks about the high quality of U-Net architecture.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.542

|| Volume 9, Issue 9, September 2021 ||

| DOI: 10.15680/IJIRCCE.2021.0909033 |

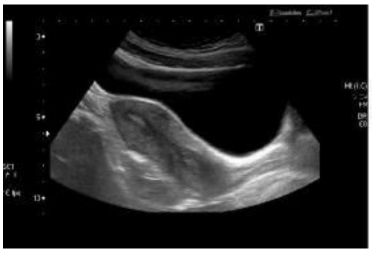


Figure 2. Original cervical image.

Figure3. Original mask

Figure4. Predicted mask (U-Net)

Figure5. Predicted mask (FCN)

V. CONCLUSION AND FUTURE SCOPE

As per the results, U-net has proven yet and again to be a boon for the biomedical image segmentation area. It is robust, and it outperforms a lot of state-of-the-art methods. It provides excellent accuracy for the segmentation of the cervix in transvaginal ultrasonic images. The preliminary analysis proved that cervix features could be used to determine preterm birth and assist the healthcare clinicians reasonably. For future work, 3D images can be used to provide a better in-depth analysis of ultrasonics. Also, datasets can be obtained from different populations worldwide, and a comparison can be made.

REFERENCES

1. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals. Lancet. 2016;388(10063):3027-35.
2. Blencowe H, Cousens S, Oestergaard M, Chou D, Moller AB, Narwal R, Adler A, Garcia CV, Rohde S, Say L, Lawn JE. National, regional and worldwide estimates of preterm birth. The Lancet, June 2012. 9;379(9832):2162-72. Estimates from 2010.
3. Density of Physicians (Total Number per 1000 Population, Latest Available Year), Global Health Observatory (GHO) Data. Situation and Trends. [Last accessed on 2018 Aug 10]. Available from: http://www.who.int/gho/health_workforce/physicians_density/en/
4. To MS, Skentou C, Liao AW, Cacho A, Nicolaides KH. Cervical length and funneling at 23 weeks of gestation in the prediction of spontaneous early preterm delivery. Ultrasound ObstetGynecol2001;18:200-03.Bauer, Stefan and Wiest, Roland and Nolte, Lutz-P and Reyes, Mauricio. (2013) “A survey of MRI-based medical image analysis for brain tumor studies.” Physics in Medicine & Biology58 (13): R97.
5. Heath VCF, Southall TR, Souka AP, Elisseou A, Nicolaides KH. Cervical length at 23 weeks of gestation: Prediction of spontaneous preterm delivery. Ultrasound ObstetGynecol 1998; 12:312-17.
6. Payal Arora, Nandita K Maitra, Shonali Agarwal. “Cervical Length Measurement by Transvaginal Ultrasound at 20 to 24 Weeks Gestation and the Timing and Mode of Delivery” 10.5005/jp-journals-10006-1165.
7. Prema, N.S.; Pushpalatha, M.P. Machine Learning Approach for Preterm Birth Prediction Based on Maternal Chronic Conditions. In Lecture Notes in Electrical Engineering; Sridhar, V., Padma, M., Rao, K., Eds; Springer: Singapore, 2019; pp. 581–588.
8. Lee, K.S.; Ahn, K.H. Artificial Neural Network Analysis of Spontaneous Preterm Labor and Birth and Its Major Determinants. J. Korean Med. Sci. 2019, 34.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.542

|| Volume 9, Issue 9, September 2021 ||

| DOI: 10.15680/IJIRCCE.2021.0909033 |

9. Rawashdeh, H.; Awawdeh, S.; Shannag, F.; Henawi, E.; Faris, H.; Obeid, N.; Hyett, J. Intelligent system based on data mining techniques for prediction of preterm birth for women with cervical cerclage. Comput. Biol. Chem. 2020, 85, 107233.
10. Koivu, A.; Sairanen, M. Predicting risk of stillbirth and preterm pregnancies with machine learning. Health Inf. Sci. Syst. 2020.

INNO SPACE

SJIF Scientific Journal Impact Factor

Impact Factor: 7.542

crossref doi

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर NISCAIR

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING