Automatic Evaluation of FHR Recordings from CTU-UHB CTG Database

Jiří Spilka¹, George Georgoulas², Petros Karvelis², Vangelis P. Oikonomou², Václav Chudáček¹, Chrysostomos Stylios², Lenka Lhotská¹, and Petr Janků³

¹ Dept. of Cybernetics, Czech Technical University in Prague, Czech Republic
² Dept. of Informatics and Communications Technology, TEI of Epirus, Arta, Greece
³ Dept. of Gynecology and Obstetrics, Teaching Hospital of Masaryk University in Brno, Czech Republic
spilka.jiri@fel.cvut.cz

Abstract. Fetal heart rate (FHR) provides information about fetal well-being during labor. The FHR is usually the sole direct information channel from the fetus – undergoing the stress of labor – to the clinician who tries to detect possible ongoing hypoxia. For this paper, new CTU-UHB CTG database was used to compute more than 50 features. Features came from different domains ranging from classical morphological features based on FIGO guidelines to frequency-domain and non-linear features. Features were selected using the RELIEF (RELevance In Estimating Features) technique, and classified after applying Synthetic Minority Oversampling Technique (SMOTE) to the pathological class of the data. Nearest mean classifier with adaboost was used to obtain the final results. In results section besides the direct outcome of classification the top ten ranked features are presented.

Keywords: fetal heart rate, intrapartum, feature selection, classification.

1 Introduction

Electronic fetal monitoring (EFM) is used for fetal surveillance during pregnancy and, more importantly, during delivery. The EFM most commonly refers to cardiotocography (CTG) that is a measurement of fetal heart rate (FHR) and uterine contractions (UC). Since its introduction the CTG has served as the main information channel providing obstetricians with insight into fetal well-being. CTG monitoring still plays a role of the most prevalent method in use for monitoring of antepartum as well as intrapartum fetal well-being. The goal of fetal monitoring is to prevent fetus of potential adverse outcomes and provide an information about his/her well-being. The main advantage of CTG, when compared to previously used auscultation technique, lies in its ability of continuous fetal surveillance though, this advantage is claimed to be insignificant in preventing adverse outcomes (with exception of neonatal seizures) as described in meta-analysis of several clinical trials [1]. The other
main controversies of CTG include: increased rate of cesarean sections [1] and high intra- and inter-observer variability [2,3].

Nowadays CTG remains the most prevalent method for intrapartum fetal surveillance [4], often supported by ST-analysis (Neoventa Medical, Sweden) which is based on analysis of fetal electrocardiogram (FECG). The introduction of additional ST-analysis into the clinical practice improved the labor outcomes slightly [5,6] but its use is not always possible or feasible since it requires invasive measurement. Moreover, in order to use ST-analysis the correct interpretation of CTG is still required.

The interpretation of CTG is based on FIGO guidelines [7] introduced in 1986, or their newer international alternatives [8]. The main goal of guidelines is to assure lowering of the number of asphyxiated neonates while keeping the number of unnecessary cesarean sections (due to false alarms) at possible minimum. Additional goal of the guidelines was to lower the high inter and intra-observer variability. Despite the efforts made, the variability of clinicians evaluation of CTG still persists [9]. Three possible ways to lower it were discussed. e.g. [10] i) by extensive training, ii) using the most experienced clinician as an oracle, iii) and/or by computerized system supporting clinicians with the decision process.

The attempts of computerized CTG interpretation are almost as old as the FIGO guideline themselves. Beginning with work of [11] the automatic analysis of CTG was aligned with clinical guidelines [12]. Beyond the morphological features used in the guidelines, new features were introduced for FHR analysis. These were mostly based on the research in the adult heart rate variability [13]. The statistical description (time domain) of CTG tracings was employed in [14] and in [15]. The spectrum of FHR either in antepartum or intrapartum period offered insight to fetal physiology, and the short review [16] described recent development in this area. The joint time-frequency analysis of FHR in the form of wavelet analysis was employed in [17]. Nonlinear methods are widely used for FHR analysis [18,19] and in our recent work we showed their usefulness in this field [20]. Different approaches were used for classification of FHR into different categories either based on pH levels, base deficit, or other clinical parameters. These approaches includes: Support Vector Machines (SVMs) [17,21,20], artificial neural networks (ANNs) [22,23], or a hybrid approach utilizing grammatical evolution [24].

The contributions of the paper are twofold: First, from the CTG point of view, the used database will be open access at the time of publication, This is one of the largest databases used for automatic evaluation of the CTG. Second, we provide a promising approach for the automatic classification of CTG using the umbilical pH value as a gold standard. The results could serve as a base methodology for a new algorithm development on clinically sound data. An overview of the procedure is shown in Fig. [1].