

Chapter XV

Gaussian–Stacking Multiclassifiers for Human Embryo Selection

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ABSTRACT

Infertility is currently considered an important social problem that has been subject to special interest by medical doctors and biologists. Due to ethical reasons, different legislative restrictions apply in every country on human assisted reproduction techniques such as in-vitro fertilization (IVF). An essential problem in human assisted reproduction is the selection of suitable embryos to transfer in a patient, for which the application of artificial intelligence as well as data mining techniques can be helpful as decision-support systems. In this chapter we introduce a new multi-classification system using Gaussian networks to combine the outputs (probability distributions) of standard machine learning classification algorithms. Our method proposes to consider these outputs as inputs for a superior-level and to apply a stacking scheme to provide a meta-level classification result. We provide a proof of the validity of the approach by employing this multi-classification technique to a complex real medical problem: The selection of the most promising embryo-batch for human in-vitro fertilization treatments.

INTRODUCTION

In-vitro fertilization (IVF) and intra cytoplasmic sperm injection (ICSI) are assisted reproduction techniques that enable infertile couples to achieve successful pregnancy under certain conditions. Intensive research is being done in this field in order to improve both the techniques and treatments applied to maximize implantation rate while limiting the number of multiple pregnancies¹. Success of the treatment is considered when pregnancy is proved by ultrasound study.

Even if these treatments have a history of several years, the success rate of pregnancy still remains very limited, around 29 % and 38 % in most of the cases (ESHRE, 2007). Success rates of IVF vary depending on many factors including causes of infertility and treatment approaches, and as an example of very optimistic results some clinics in France and the USA have reported pregnancy rates of up to 40%.

In order to improve this success rate, it is essential to select the most promising batch of embryos to be transferred in a patient, although there are also additional important features that need to be taken into account since they affect the final outcome of the treatment. Among the latter we can mention age, presence of oocyte dimorphism's, sperm quality, fertilization rate, cleavage rate and number of embryos transferred, endometrial thickness and number of previous cycles of treatment. Apart from the selection of the most suitable embryos, embryologists need to consider several possibilities when deciding which type of treatment to apply, among them the number of embryos to transfer, pre-implantation genetic diagnosis, the type of assisted reproduction technique, and the composition of culture media.

Infertility research trends include developments in medical technology on assisted human reproduction in aspects such as medical treatments, equipment technology, and also on the application of artificial intelligence. The latter combines both advances on clinician and embryologist expertise together with data mining techniques, by providing classification models able to be applied as decision-support systems. The final aim is to classify each of the possible embryos for transfer and select the ones that would have the highest probability to implant successfully.

Since it is very unlikely that a single classification paradigm performs best for all types of problems regarding the complexity and the quality of the databases available, one of the trends nowadays is to combine multiple algorithms to improve the overall classification performance. This carries out the application of different classification models from the same knowledge (e.g. data), with a posterior technique that gathers all the information and provides a prediction. When using this approach, the basic classification models are called *base-level classifiers* and the classification technique that gathers all inputs and provides an overall conclusion is referred to as *meta-level classifier*.

Actually, the way of combining the output scores of the different base-level classifiers in order to build a meta-level classifier is a major problem in the combination of different classification systems, and the literature provides examples of several approaches in which voting systems or weights are applied for this aim (Kuncheva, 2004). Stacking (Wolpert, 1992) is an alternative approach of combining base-level classifiers that is characterized by its ability to take into account the class probability distributions of base-level classifiers. This method has been very successfully applied in general classification domains and that has been applied only very recently to medical classification problems (Sierra et al, 2001). Due to the capability of stacking to further combine the knowledge represented in each classifier, in this Chapter we focus on an extension introduced by Wolpert (1992) called stacked generalization, and we propose to improve it applying a Gaussian meta-learning method to the supervised classification framework.

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