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Auto machine learning to predict pregnancy after fresh embryo transfer following in vitro fertilization

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Abstract

Introduction: The use of human reproduction techniques (ART) to obtain pregnancy are increasing. However pregnancy rates after ART remain as low as around 30%. The use of machine Learning (ML) is increasing in medicine and prediction models are helpful to preview the outcome of in vitro fertilization(IVF) cycles.

Methods: Data from IVF cycles with fresh embryo transfer between January 2018 and December 2021 were collected. The Auto Machine Learning (Auto ML) PyCaret was used to construct the model and predict the clinical pregnancy rate.

Results: Among 14 ML algorithms, Ridge Classification (RC) has the best accuracy(57,69%). Transfer in day 5 was the most important feature related to the outcome.

Conclusion: Despite the low accuracy as a result of a small sample, familiarization with ML models, as well as awareness of the importance of data collection should be part of daily activities of physicians and healthcare professionals in the field of ART.

Keywords: IVF; Machine Learning; Artificial Intelligence; Infertility; Prediction model

1. Introduction

Despite being technologically advanced, ART techniques have been shown to be unable to deliver pregnancy rates greater than 30% after a first cycle[1]. Several variables interfere with the results, such as the cause of infertility, the woman´s age, body mass index(BMI), lifestyle, among others[2].

Predict the outcome of an IVF cycle is challenging for the physician and other healthcare professionals involved in the treatment. In this way, the use of technology could be an important tool not only to improve pregnancy rates but also to assess the success chances.

For many years men have been looking the machine help to solve many tasks. Not only the mechanization of activities, but also the resolution of problems whose solutions may lie in the analysis of large number of data are examples of activities whose machines have been helping men over time. The ML can be especially useful in these situations, in several areas, including medicine.

The term ML is not new. Arthur Samuel was the pioneer in the filed of computer gaming and artificial intelligence (AI) and popularized the term ML in 1959[3]. It is an application if AI that allows automatic learning from a large number of

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data. Statistical methods associated with the efficiency of computing algorithms combine mathematics and computer science to solve problems[4].

Several areas of medicine have recently used ML algorithms to increase efficiency, such as epidemiology [5]., new drugs research[6]. anesthesiology[7]. among others. The scenario is no different in ART. Initially used for embryo selection from the analysis of their images by AI[8]. its use has also been growing in the area of clinical decision-making.

In 2019, Curchoe and Bormann[9].published a compilation of works presented at the two 2108 ART largest international meetings. The authors identified 16 studies that included a series of aspects such as semen analysis, prediction of embryo formation, embryo selection, live births prediction, among others.

Yiğit et al recently published a comparison of various ML techniques in predict IVF cycles success [10]. Logistic Regression (LR), Decision Tree (DT), Naïve Bayes (NB), Random Forest (RF), Support Vector Machine (SVM), Neural Network (Nnet), Gradient Boost Decision Tree (GBDT), eXtreme Gradient Boosting (XGBoost) and Super Learner (SL) were the ML algorithms used. The best performances were attributed to the RF and SL models, which showed as accuracy of 89% in predicting pregnancy, also identifying maternal age as the most import feature.

Selecting the algorithm to be used, optimizing the data and tunning the hyperparameters requires great experience and can lead to sub-optimal choices. Therefore, Auto ML techniques emerged as an alternative to simplify the process, automating part of these steps[11].However, Auto ML does not replace the data scientist. It just supports this professional. With less code, the time dedicated to analysis and decision is amplified.

2. Material and methods

From January 2018 to December 2021, 2018 IVF cycles were performed at Vida Centro de Fertilidade, Rio de Janeiro, Brazil. Of this, in 187 cases fresh embryo transfers were done. In the other cases, embryos were either not generated or, for different reasons, were frozen for later transfer.

Cases with missing data were excluded, leaving a total of 171 cases for analysis. The variables age, BMI, total dose of gonadotropins, the number of days of avarian stimulation, the number of embryos transferred (1 or 2) and how many days after the oocyte collection the embryos were transferred to the uterus were analyzed. The outcome was the achievement of clinical pregnancy.

The Auto ML library chosen was PyCaret version 3.0. The construction of the model was carried out in Python using the Google Collaboratory cloud service. Pandas 1.3 and numpy 1.19 libraries were used. The sample was divided into training and testing in a 80/20 ratio. PyCaret´s setup included all available algorithms.

In the next step, the algorithm with highest accuracy was selected for automatic hyperparameters tuning. Model accuracy, area under the curve(AUC), precision, recall and the most important feature were evaluated.

3. Results

Among the 14 classification models(Ridge Classifier, Logistic Regression, SVM-Linear Kernel, Random Forest Classifier, Linear Discriminant Analysis, K Neighbors Classifier, Extra Trees Classifiers, Dummy Classifier, Quadratic Discriminant Analysis, Gradient Boosting Classifier, Ada Boost Classifier, Decision Tree Classifier, Light Gradiente Boosting Machine e Naïve Bayes), the RC algorithm was the most accurate, which after hyperparameter tuning reached 0.5769. The AUC, recall, precision and F1 score were respectively 0.5704, 0.4, 0.5882 and 0.4762(Table 1).

Table 1 Summary results

Model	Accuracy	AUC	Recall	Precision
Ridge Classifier	0.5769	0.5704	0.4	0.5882

The Precision-Recall curve is in figure 1, showing an average accuracy of 0.59.

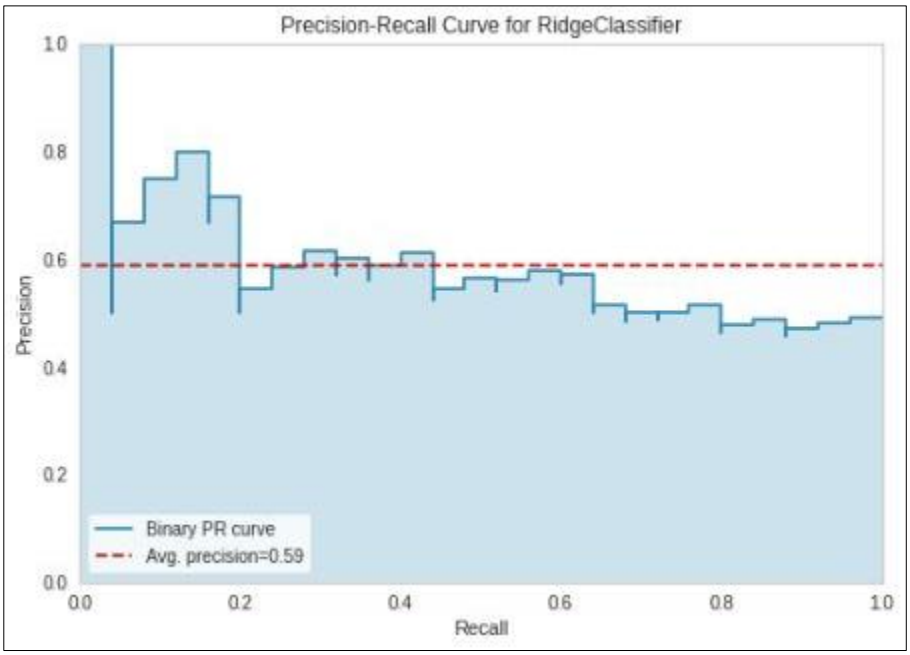

Figure 1 Precision-Recall Curve

As an alternative to a confusion matrix, we created a table to demonstrate the prediction errors and successes (figure 2).

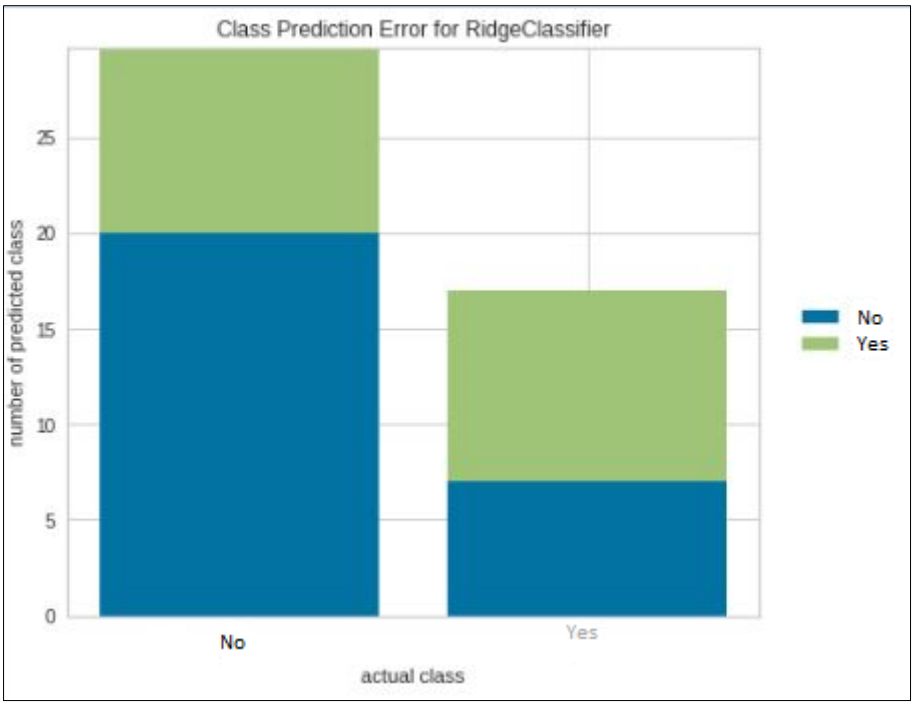

Figure 2 Class Prediction Error

The most important feature was the embryo transfer on day 5. Figure 3 illustrates the most features and their respective weights.

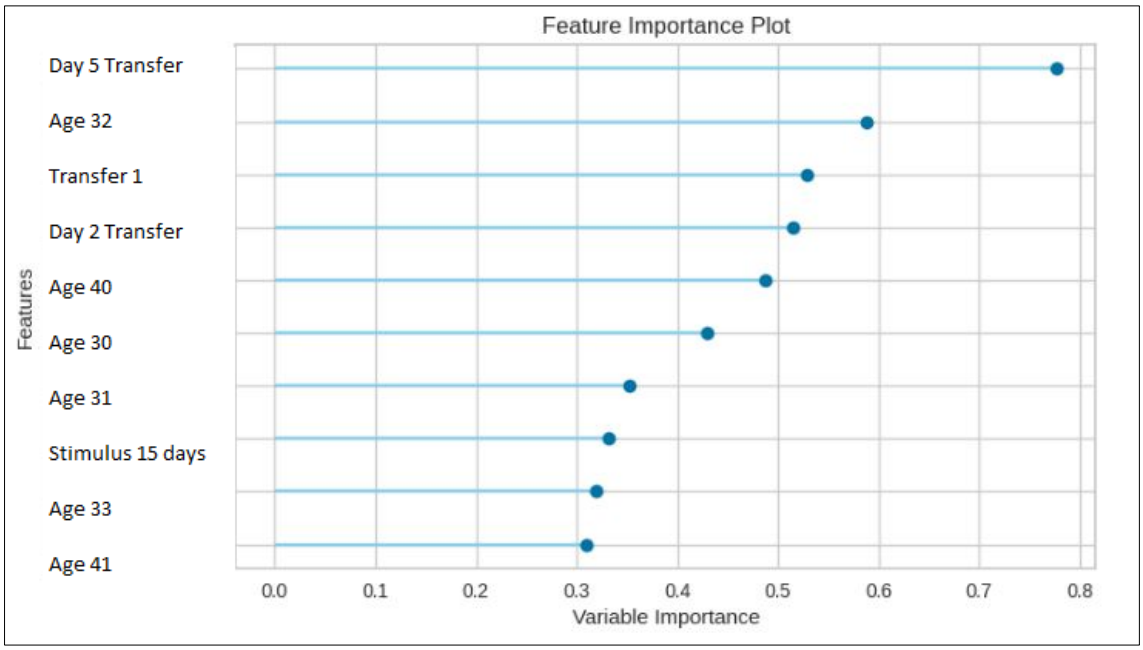

Figure 3 Feature Importance

The pregnancy rate found in our sample was 43.27%(74/171).

4. Discussion

IVF cycles are increasing in the world, not only due to infertility expansion but also for other reasons such as homosexual couples and single mothers [12, 13]. However, get pregnant is still not achieved by even half of the women who seek this form of treatment [14].. Over the last few years, several predictive models have been developed to evaluate and try to predict the results of an IVF treatment [15]. Thes ML models, initially dedicated to embryo selection [16] have been advanced to the area of clinical decision and predictive model development [17]..

Fu *et al*. recently published a work on the development of a predictive model after IVF cycles finding a final AUC of 0.704 with a consistency of 98.1%. To this end, more than 37 thousand IVF cycles and 38 features were analyzed [18].. Considering that an ML model learns from data, usually larger databases produce better results. Some alternatives have been proposed to deal with small samples [19]. .

In our case, despite the fact that more than 2000 IVF cycles were performed in our center during the chosen period, only those where there was a fresh transfer of embryos were ready for analysis, reducing the sample size, which probably contributed to a low model accuracy.

Likewise, some variables related to pregnancy chances such as anti-Mullerian hormone (AMH) [20] dosage and endometrial quality[21] were not available for analysis in our sample, reducing the number of features.

In our sample, the pregnancy rate was higher than that published by the European Society of Human Reproduction and Embryology for all European countries in 2017[14]. However, despite the high pregnancy rate, the number of cases considered for analysis was low for the reasons explained above.

Despite the low accuracy of the model, some objectives were achieved such as the familiarization of the team with ML models ans AI, as well as a beter understanding of the importance of collecting data for further analysis.

5. Conclusion

Despite a small number of cases available for analysis, the Auto ML model used was able to predict the chance of pregnancy after fresh embryo transfer with an accuracy of more than 56%. Embryo transfer on day 5 was the most important factor.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest.

References

[1] McLernon D, Steyerberg E, te Velde E, Lee A, Bhattacharya S. Predicting the chances of a live birth after one or more complete cycles of in vitro fertilisation: Population based study of linked cycle data from 113 873 women. BMJ. 2016; 355: i5735. doi:10.1136/bmj.i5735.

[2] Carson SA, Kallen, AN. Diagnosis and management of infertility. JAMA 2021;326(1):65-76.

[3] Handelman GS, Kok HK, Chandra RV, Razavi AH, Lee AJ, Asadi H. eDoctor: machine learning and the future of medicine. J Intern Med 2018; 284(6):603-19.

[4] Deo RC. Machine learning in medicine. Circulation 2018;132(20):1920-30.

[5] Bi Q, Goodman KE, Kaminsky J, Lessler J. What is machine learning? A primer for the epidemiologist. Am J Epidemiol 2019; 188(12):2222-39.

[6] Patel L, Shukla T, Huang X, Ussery DW, Wang S. Machine learning methods in drug discovery. Molecules 2020; 25(22): 5277.

[7] Connor CW. Artificial intelligence and machine learning in anesthesiology. Anesthesiology 2019; 131(6):1346-59.

[8] Tran D, Cooke S, Illingworth PJ, Gardner DK. Deep learning as a predictive tool for fetal heart pregnancy following time-lapse incubation and blastocyst transfer. Human Reproduction 2018; 34(6):1011-18.

[9] Curchoe CL, Bormann CL. Artificial intelligence and machine learning for human reproduction and embryology at ASRM ans ESHRE 2018. J Asist Reprod Genet 2019;36:591-600.

[10] Yiğit P, Bener A, Karabulut S. Comparison of machine learning classification techniques to predict implantation success in an IVF treatment cycle. Reprod Biomed Online 2022;S1472-6483(22)00481. doi: 10.1016/j.rbmo.2022.06.022.

[11] Kausar F, Awadalla M, Mesbah M, AlBadi T. Automated machine learning based elderly fall detection classification. Procedia Computer Science 2022; 203:16-23.

[12] Hanevik HI, O Hessen D. IVF and human evolution. Hum Reprod Update 2022;28(4):457-479. doi: 10.1093/humupd/dmac014.

[13] Meads C, Thorogood LR, Lindemann K, Bewley S. Why are proposrtions of in-vitro fertilization interventions for same sex couples increasing? Healthcare(Basel) 2021;9(12):1657. doi: 10.3390/healthcare9121657

[14] European IVF-Monitoring Consortium (EIM) for the European Society of Human Reproduction and Embryology (ESHRE), Wyns C, De Geyter C, Calhaz-Jorge C, Kupka MS, Motrenko T, Smeenk J, Bergh C, Tandler-Schneider A, Rugescu IA, Vidakovic S, Goossens V. ART in Europe, 2017: results generated from European registries by ESHRE. Hum Reprod Open. 2021 Aug 5;2021(3):hoab026. doi: 10.1093/hropen/hoab026. PMID: 34377841; PMCID: PMC8342033.

[15] Ratna MB, Bhattacharya S, Abdulrahim B, McLernon DJ. A Systematic Review of the Quality of Clinical Prediction Models in In Vitro Fertilisation. Hum Reprod (2020) 1:100–16. doi: 10.1093/humrep/ dez258

[16] Khosravi P, Kazemi E, Zhan Q, Malmsten JE, Toschi M, Zisimopoulos P, et al. Deep Learning Enables Robust Assessment and Selection of Human Blastocysts After In Vitro Fertilization. NPJ Digit Med (2019) 2:21. doi: 10.1056/NEJMp1606181

[17] Barnett-Itzhaki Z, Elbaz M, Butterman R, Amar D, Amitay M, Racowsky C, et al. Machine Learning vs. Classic Statisticsfor the Prediction of IVF Outcomes.J Assist Reprod Genet (2020) 10:2405–12. doi: 10.1007/s10815-020-01908-1

[18] Fu K, Li Y, Lv H, Wu W, Song J, Xu J. Development of a Model Predicting the Outcome of *In Vitro* Fertilization Cycles by a Robust Decision Tree Method. Front Endocrinol (Lausanne). 2022 Aug 24;13:877518. doi: 10.3389/fendo.2022.877518. PMID: 36093079; PMCID: PMC9449728.

[19] Zonglei Lu, Xiaohan Geng, Guoming Chen. A Bayesian assumption based forecasting probability distribution model for small samples. Computers & Electrical Engineering 2018;70:883-894.https://doi.org/10.1016/j.compeleceng.2017.11.025.

[20] Moolhuijsen LME, Visser JA. Anti-Müllerian Hormone and Ovarian Reserve: Update on Assessing Ovarian Function. J Clin Endocrinol Metab. 2020 Nov 1;105(11):3361–73. doi: 10.1210/clinem/dgaa513. PMID: 32770239; PMCID: PMC7486884.

[21] Shaulov T, Sierra S, Sylvestre C. Recurrent implantation failure in IVF: A Canadian Fertility and Andrology Society Clinical Practice Guideline. Reprod Biomed Online. 2020 Nov;41(5):819-833. doi: 10.1016/j.rbmo.2020.08.007. Epub 2020 Aug 20. PMID: 32962928.