Flu Shot Learning: Predicting H1N1 and Seasonal Flu Vaccination

Jorge Pais, José Baptista and Pedro Duarte
up201904841@edu.fe.up.pt; up201904814@edu.fe.up.pt; up201905050@edu.fe.up.pt

***Abstract*—The model used in this study was a gradient boosting classifier, which was evaluated on separate test data provided by the NHFS using the area under the Receiver Operating Characteristic (ROC) curve as a performance metric. After necessary parameter tuning, the model was able to achieve a score of 0.8415.**

I. Introduction

Pandemics have rarely taken center stage in the way they have recently with COVID-19 in 2020. Vaccines are a key public health measure used to fight infectious diseases like COVID-19. They provide immunization for individuals, and enough immunization in a community can further reduce the spread of diseases through ”herd immunity.” We will look at a recent historical pandemic, also of a highly infectious respiratory disease: the 2009 H1N1 influenza pandemic.

In 2009, the H1N1 influenza virus, also known as swine flu, caused a global pandemic that was estimated to have resulted in 150,000 to 600,000 deaths worldwide. A vaccine for H1N1 became available in October of that year. In this study, we developed a machine learning model to help estimate the probability of a person receiving seasonal and H1N1 vaccines. *Dar alguma contextualizacao do que é que vai ser construido neste trabalho*

II. Data Set Analysis / Data Resources

A. DataSet

In this research work, the dataset used was provided by DrivenData, and it comes from the National 2009 H1N1 Flu Survey (NHFS) which included 36 attributes and was collected through telephone interviews. The dataset consists of 36 columns (attributes) of which respondent id is unique and 35 other columns out of which most of them were binary type and others were of ordinal type. The goal was to predict the probability of a person receiving seasonal and H1N1 vaccines. The predicted values were later evaluated based on the ROC curve. The problem falls under multilabel problem, not a multiclass problem.

B. Data Cleaning and Pre-processing

The first step in the data analysis was to check if the data has any duplicate and missing values, duplicates were not observed, but the dataset had many missing values in different attributes ranging from 19 to 13470. So, our first concern was to clean the data. Since the attributes employment concern and employment occupation had the highest missing data (13470 values) we decided to drop the same along with respondent id as it was of no use. The next step involved checking of correlation between the attributes. This was done using the seaborn library's correlation heatmap. It was noted that two attributes named doctor recc H1N1 vaccine and doctor recc seasonal vaccine attributes were positively correlated by 60%.

Hence, only one attribute has been retained. In the next step, the missing data were handled. Two different imputation methods are implemented in this project, the first one being median imputation and the second one, the one-hot encoder. The algorithms and packages used in this work require numeric data, and not categorical data. Therefore, a unique numerical value is assigned to each category in the object columns. This method can cause problems, as the model might not recognize the data as categorical and would process it on a scale. This leads to incorrect weight assignments. To avoid this problem, one-hot encoder is used, which encodes a category in a 1-hot vector, where the position in the vector refers to each category and its size is equal to the number of categories. Simple imputer is used to fill in missing data using median method. The Pandas library in Python identifies missing values as NaN. After the data is cleaned and pre-processed, graphical visualizations are generated.

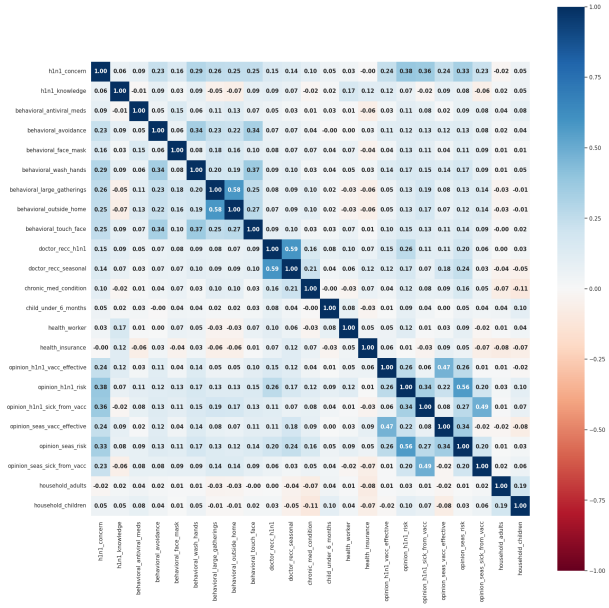

Figure 1 - Feature Correlation Heatmap

C. Class Balance

Different attributes are plotted to check how the data is distributed. Firstly, it is observed that out of the people who received the seasonal vaccine, most of them were female. The same case was also observed with H1N1 vaccine through which one can conclude that women are more prone to get affected than men.

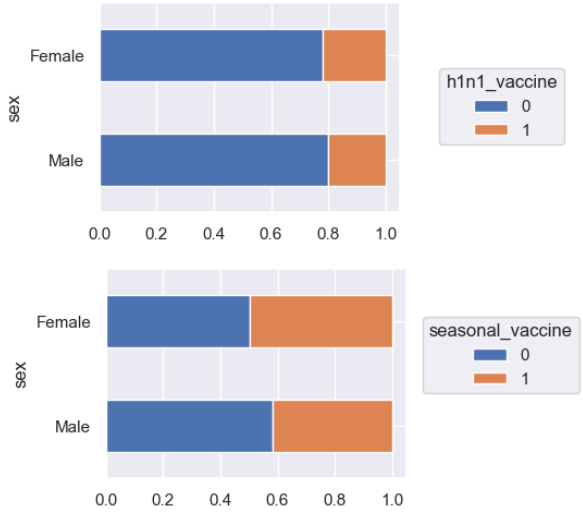

Figure 2 - Vaccination for male and female

The age group has a strong correlation with the seasonal flu vaccine but not with the H1N1 flu vaccine. It seems that people act appropriately when it comes to the seasonal flu as older individuals have a higher risk of complications. However, with H1N1 flu, even though older individuals have a higher risk of complications, they are less likely to get infected. This analysis does not provide information about causality, but it seems that the risk factors are reflected in vaccination rates. It appears that questions related to knowledge and opinions have a strong correlation with both target variables. Finally we got a graph to conclude white people received the highest vaccination than any other race that is depicted which is more evident with the seasonal flu vaccine, but not as much with the H1N1 flu vaccine.

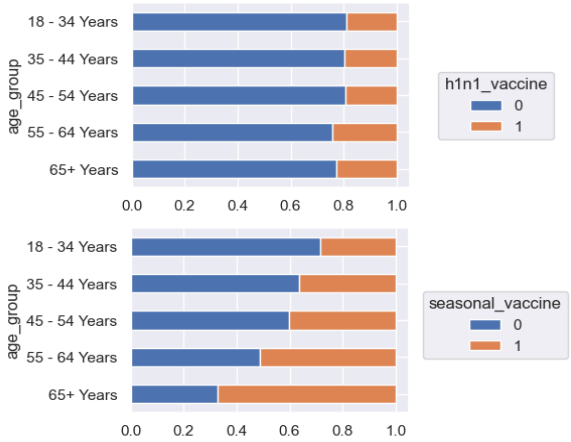

Figure 3 - Vaccination for different age groups

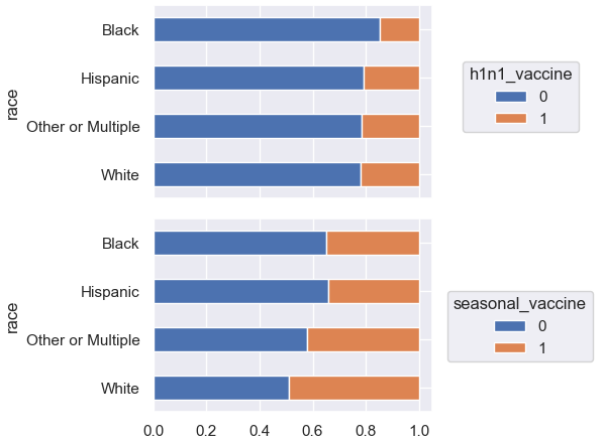

Figure 4 - Vaccination for different race

III. Performance Metric

IV. Model Pipeline

Talvez seja melhor condensar esta secção com a proxima, sob metodologia
Meter aqui aquelas figuras do model pipeline, e mostrar o esquema lógico do que vai ser construido

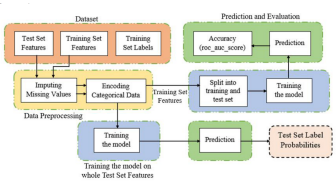

Figure 3.x.x - Model pipeline example

V. Models

Meter aqui todos os modelos que foram experimentados

VI. Results

VII. Conclusion

VIII. Reference Examples

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  See [32], [33].
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  See [34].

References

[1] G. O. Young, "Synthetic structure of industrial plastics," in *Plastics,* 2nd ed., vol. 3, J. Peters, Ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15–64.

[2] W.-K. Chen, *Linear Networks and Systems.* Belmont, CA, USA: Wadsworth, 1993, pp. 123–135.

[3] J. U. Duncombe, "Infrared navigation—Part I: An assessment of feasibility," *IEEE Trans. Electron Devices*, vol. ED-11, no. 1, pp. 34–39, Jan. 1959, 10.1109/TED.2016.2628402.

[4] E. P. Wigner, "Theory of traveling-wave optical laser," *Phys. Rev*., vol. 134, pp. A635–A646, Dec. 1965.

[5] E. H. Miller, "A note on reflector arrays," *IEEE Trans. Antennas Propagat*., to be published.

[6] E. E. Reber, R. L. Michell, and C. J. Carter, "Oxygen absorption in the earth's atmosphere," Aerospace Corp., Los Angeles, CA, USA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.

[7] J. H. Davis and J. R. Cogdell, "Calibration program for the 16-foot antenna," Elect. Eng. Res. Lab., Univ. Texas, Austin, TX, USA, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

[8] *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, USA, 1985, pp. 44–60.

[9] *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, USA, 1989.

[10] G. O. Young, "Synthetic structure of industrial plastics," in Plastics, vol. 3, Polymers of Hexadromicon, J. Peters, Ed., 2nd ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15-64. [Online]. Available: http://www.bookref.com.

[11] *The Founders' Constitution*, Philip B. Kurland and Ralph Lerner, eds., Chicago, IL, USA: Univ. Chicago Press, 1987. [Online]. Available: http://press-pubs.uchicago.edu/founders/

[12] The Terahertz Wave eBook. ZOmega Terahertz Corp., 2014. [Online]. Available: http://dl.z-thz.com/eBook/zomega_ebook_pdf_1206_sr.pdf. Accessed on: May 19, 2014.

[13] Philip B. Kurland and Ralph Lerner, eds., *The Founders' Constitution.* Chicago, IL, USA: Univ. of Chicago Press, 1987, Accessed on: Feb. 28, 2010, [Online] Available: http://press-pubs.uchicago.edu/founders/

[14] J. S. Turner, "New directions in communications," *IEEE J. Sel. Areas Commun*., vol. 13, no. 1, pp. 11-23, Jan. 1995.

[15] W. P. Risk, G. S. Kino, and H. J. Shaw, "Fiber-optic frequency shifter using a surface acoustic wave incident at an oblique angle," *Opt. Lett.*, vol. 11, no. 2, pp. 115–117, Feb. 1986.

[16] P. Kopyt *et al.,* "Electric properties of graphene-based conductive layers from DC up to terahertz range," *IEEE THz Sci. Technol.,* to be published. DOI: 10.1109/TTHZ.2016.2544142.

[17] PROCESS Corporation, Boston, MA, USA. Intranets: Internet technologies deployed behind the firewall for corporate productivity. Presented at INET96 Annual Meeting. [Online]. Available: http://home.process.com/Intranets/wp2.htp

[18] R. J. Hijmans and J. van Etten, "Raster: Geographic analysis and modeling with raster data," R Package Version 2.0-12, Jan. 12, 2012. [Online]. Available: http://CRAN.R-project.org/package=raster

[19] Teralyzer. Lytera UG, Kirchhain, Germany [Online]. Available: http://www.lytera.de/Terahertz_THz_Spectroscopy.php?id=home, Accessed on: Jun. 5, 2014

[20] U.S. House. 102nd Congress, 1st Session. (1991, Jan. 11). *H. Con. Res. 1, Sense of the Congress on Approval of Military Action.* [Online]. Available: LEXIS Library: GENFED File: BILLS

[21] Musical toothbrush with mirror, by L.M.R. Brooks. (1992, May 19). Patent D 326 189 [Online]. Available: NEXIS Library: LEXPAT File: DES

[22] D. B. Payne and J. R. Stern, "Wavelength-switched pas- sively coupled single-mode optical network," in *Proc. IOOC-ECOC,* Boston, MA, USA, 1985, pp. 585–590.

[23] D. Ebehard and E. Voges, "Digital single sideband detection for interferometric sensors," presented at the *2nd Int. Conf. Optical Fiber Sensors,* Stuttgart, Germany, Jan. 2-5, 1984.

[24] G. Brandli and M. Dick, "Alternating current fed power supply," U.S. Patent 4 084 217, Nov. 4, 1978.

[25] J. O. Williams, "Narrow-band analyzer," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, USA, 1993.

[26] N. Kawasaki, "Parametric study of thermal and chemical nonequilibrium nozzle flow," M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

[27] A. Harrison, private communication, May 1995.

[28] B. Smith, "An approach to graphs of linear forms," unpublished.

[29] A. Brahms, "Representation error for real numbers in binary computer arithmetic," IEEE Computer Group Repository, Brief R-67-85.

[30] IEEE Criteria for Class IE Electric Systems, IEEE Standard 308, 1969.

[31] Letter Symbols for Quantities, ANSI Standard Y10.5-1968.

[32] R. Fardel, M. Nagel, F. Nuesch, T. Lippert, and A. Wokaun, "Fabrication of organic light emitting diode pixels by laser-assisted forward transfer," *Appl. Phys. Lett.*, vol. 91, no. 6, Aug. 2007, Art. no. 061103.

[33] J. Zhang and N. Tansu, "Optical gain and laser characteristics of InGaN quantum wells on ternary InGaN substrates," *IEEE Photon. J.*, vol. 5, no. 2, Apr. 2013, Art. no. 2600111

[34] S. Azodolmolky *et al.*, Experimental demonstration of an impairment aware network planning and operation tool for transparent/translucent optical networks," *J. Lightw. Technol.*, vol. 29, no. 4, pp. 439–448, Sep. 2011.