LEPL1109 - Statistics and Data Sciences
HACKATHON 2 - Diabetes health indicators

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Please, read carefully the following guidelines:

- Answer in English, with complete sentences and correct grammar. Feel free to use grammar checker tools such as LanguageTools free and open-source plugin;
- Do not modify questions, and input all answers inside `\begin{answer}...\end{answer}` environments;
- Each question should be followed by an answer;
- At the end of each question, there is the length of the expected answer. This is for your information but it is not too important if you do not respect these recommendations.
- Clearly cite every source of information (even for pictures!);
- Whenever possible, use the `.pdf` format when you export your images: this usually makes your report look prettier[1];
- Do not forget to also submit your code on Moodle.
- **Reminder:** You need to belong to a group to submit your project on Moodle.

Contents

[1] This is because `.pdf` is a vector format, meaning that it keeps a perfect description of your image, while `.png` and other standard formats use compression. In other words, this means you can zoom as much as you want on your figure without decreasing image resolution. For simple plots, vector formats can also save a lot of memory space. On the other hand, we recommend using `.png` when you are plotting many data points: large scatter plots, heatmap, etc.

1 Description of the project

1.1 Your objective

You work in the diabetology department at **Saint Luc University Hospital**. The head of the department has asked you to find a solution for classifying and predicting **whether patients are at high risk of developing diabetes**. This will enable them to schedule an appointment with these patients to set up prevention tools. To do this, you have a database of patients who have passed through the department in recent years. In addition, the head of the department feels that the poll is too long, and would like to **reduce the number of questions while maintaining the reliability and quality of the results**. The attached `.ipynb` file will guide you in this process.

Your aim is to determine which characteristics are relevant and enable reliable patient classification. **Be careful**, don't let a potential diabetic patient slip through the cracks.

1.2 The dataset

The dataset is a real dataset based on a questionnaire carried out in the USA some ten years ago. It contains around 70 000 entries and is a collection of 22 features individually defined in table 1.

Features name	**Description**	**Range**
`Diabetes`	Diabetes (0:no diabetes; 1:diabetes)	{0, 1}
`HighBP`	High blood pressure (0:no; 1:yes)	{0, 1}
`HighChol`	High cholesterol (0:no; 1:yes)	{0, 1}
`CholCheck`	Cholesterol check in 5 years (0:no; 1:yes)	{0, 1}
`BMI`	Body mass index in [kg/m^2]	/
`Smoker`	Smoked at least 100 cigarettes in your life (0:no; 1:yes)	{0, 1}
`Stroke`	Stroke (0:no; 1:yes)	{0, 1}
`HeartDisease`	Heart disease (0:no; 1:yes)	{0, 1}
`PhysActivity`	Physical activity in past 30 days (0:no; 1:yes)	{0, 1}
`Fruits`	Consume fruit 1 or more times per day (0:no; 1:yes)	{0, 1}
`Veggies`	Consume vegetables 1 or more times per day (0:no; 1:yes)	{0, 1}
`Alcohol`	Heavy alcohol drinkers (0:no; 1:yes)	{0, 1}
`AnyHelathcare`	Health insurance (0:no; 1:yes)	{0, 1}
`NoDocbcCost`	No doctor because of cost (0:no; 1:yes)	{0, 1}
`GenHlth`	General health (1:excellent; 5:poor)	{1, . . . , 5}
`MenHlth`	Number of days out of the last 30 when mental health was poor	{0, . . . , 30}
`PhysHlth`	Number of days out of the last 30 when physical health was poor	{0, . . . , 30}
`DiffWalk`	Serious difficulty for walking (0:no; 1:yes)	{0, 1}
`Sex`	0:female; 1:male	{0, 1}
`Age`	Age category (1:18-24; . . . ; 13:80 or older)	{1, . . . , 13}
`Education`	Education level (1:never; 6:university)	{1, . . . , 6}
`Income`	Income scale (1:less than $10,000; . . . ; 8:$75,000 or more)	{1, . . . , 8}

Table 1: Data set features

2 Questions and answers (4/10)

Question 2.1:

(1/10) What happens to the precision and recall (of any method) when the threshold tends to 0? And when it tends to 1? How can you explain it?
Expected answer length : 8 lines.

Answer to 2.1:

When the threshold of a method tends to 0, almost all instances are predicted as positive. This results in high recall, meaning that most true positives are captured but with low precision, meaning that many false positives are also captured. When the threshold of a method tends to 1, unlike the case above, almost all instances are predicted as negative. This results in high precision, having few false positives, but with low recall, where many true positives are missed. This happens because the threshold determines how strict the model is in predicting a positive label. Lower thresholds favor recall at the cost of precision, while higher thresholds favor precision at the cost of recall.

Question 2.2:

(1/10) Explain which precision/recall trade-off you prefer to have for the specific task asked in this hackathon: don't let a potential diabetic slip through the cracks. How should you adjust the threshold of your model to bring it closer to the desired trade-off? Should it be above or below the default threshold value of 0.5?
Expected answer length : 5 lines.

Answer to 2.2:

In this task, we prefer a high **recall** to ensure that we identify all potential diabetics and don't miss any cases ("don't let a potential diabetic slip through the cracks"). This means we're willing to accept more false positives to avoid false negatives. To achieve a higher recall, we should **lower the classification threshold below 0.5**. By decreasing the threshold, the model classifies more instances as positive, increasing the chance of detecting all actual diabetics. Therefore, adjusting the threshold **below** the default value brings the model closer to the desired trade-off.

Question 2.3:

(1/10) Based on your code, select a final model that you will keep as classifier. **Justify.**
Expected answer length : 5 lines.

Answer to 2.3:

Based on the code and results, We select the Logistic Regressor using all 21 features** with a threshold of 0.2 as the final classifier. This model achieved an average recall of 96.73% and an F1 score of 75.05%, satisfying the specified criteria. The high recall ensures that we effectively identify potential diabetic cases without letting them "slip through the cracks," while the acceptable F1 score indicates a good balance between precision and recall.

Question 2.4:

(1/10) Could you reduce the length of the questionnaire? If so, how many questions? Which questions? **Justify.**
Expected answer length : 6 lines.

Answer to 2.4:

Yes, the questionnaire can be reduced to 6-7 essential questions. These questions are (1) Is the dataset balanced and what preprocessing is required? (2) Which features correlate most strongly with diabetes? (3) What is the minimum number of features to meet the recall ($\geq 95\%$) and F1 ($\geq 75\%$) thresholds? (4) Which classifier performs best? (5) What is the optimal threshold? (6) How can the results be visualised efficiently? In this reduction, we avoid redundant steps while combining similar objectives and focusing on key ideas. This ensures efficiency without compromising the project objectives.

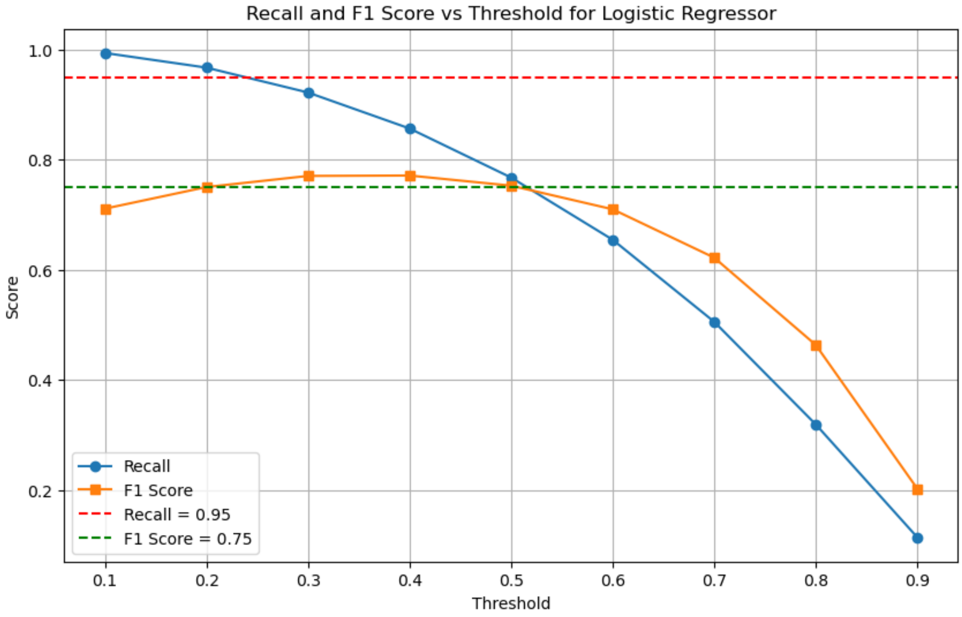
3 Visualization (2/10)

Question 3.1:

(2/10) To answer this question, we ask you to produce a clear, clean figure expressing a result or giving an overall vision of your work for this hackaton. Please feel free to do as you wish. Be original! The clarity, content and description of your figure will be evaluated.
Justify.
Expected answer length : 4 lines + 1 figure

Answer to 3.1:

The figure shows the performance of the logistic regressor as a function of different thresholds. The optimal threshold around 0.2 balances these measures, achieving high recall (>95%) and a sufficient F1 score (>75%). This choice is in line with the objective of minimizing undetected diabetes cases.


Recall and F1 Score vs Threshold for Logistic Regressor
Score
1.0
0.8
0.6
0.4
0.2
Threshold
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Recall
F1 Score
Recall = 0.95
F1 Score = 0.75