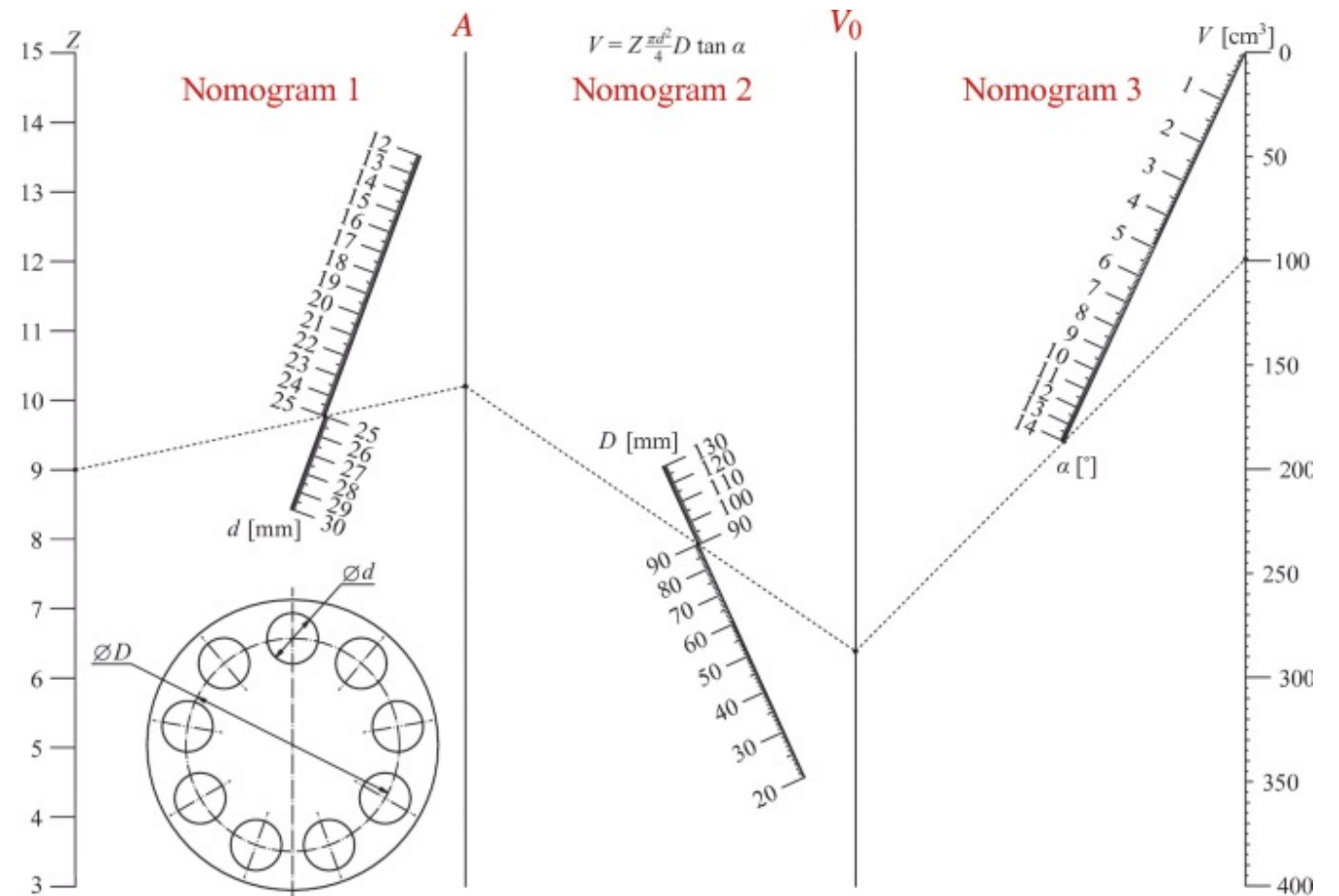


Probabilistic Nomograms

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What is a nomogram?

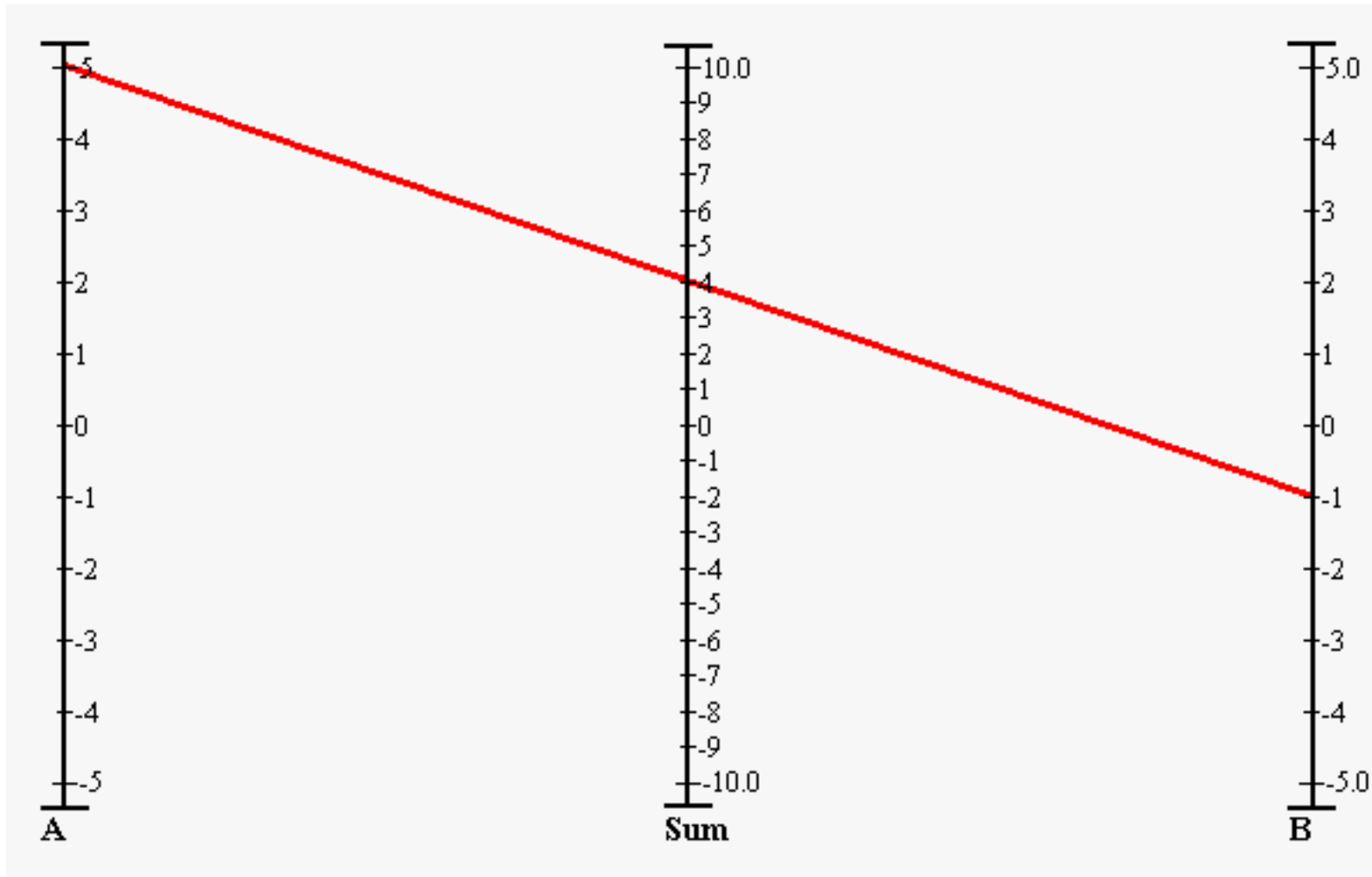


Figure 1: A simple addition nomogram.

Presentation Outline

- In this presentation, I will be introducing you to nomography, and how we can create interactive visualisations of complex calculations where one or more values in an equation are unknown and distributed by probability distributions.

User Scenarios

- Mike uses a nomogram with probabilistic distributions that combine factors like genetic predisposition, lifestyle choices, and environmental exposure to estimate the patient's risk of developing cancer. This nomogram visually represents the patient's risk and helps the doctor determine the appropriate screening and prevention strategies.
- Helen is working with a client with a unique financial profile, including income, credit score, and debt-to-income ratio. Based on these factors, Helen would use a nomogram with probabilistic distributions to calculate the likelihood of the client getting approved for a mortgage. The nomogram considers historical data on mortgage approvals and provides the broker with a visual representation of the client's approval chances.

Benefits of Nomograms in 2024

- Nomograms still offer various advantages.

“1. it can be attractive and provoke interest, potentially because nomograms are unusual,
2. it might provide the basic skills to design and interpret nomograms, avoiding that this centenary knowledge might become utterly extinct from universities,
3. it would contribute to a better understanding of complex formulas and how are associated with their variables, as well as the sensitivity of the results to changes in those variables,
4. it may help those people who prefer pictures to equations understand the inputs and results of complex calculations...”

(Martínez-Pagán and Roschier 2022)

Understanding probabilistic computations

- Challenges in understanding probabilistic computations are multifaceted and have significant implications for their learning outcomes. Despite probability theory's crucial role in everyday life and various disciplines, students and professionals often encounter difficulties grasping its concepts and applying them effectively in problem-solving scenarios. (Arum et al. 2018)

Requirements

Functional requirements

- Import a nomogram and be able to select the axis, their values and ranges.
- Move around an isopleth line to see the values of all variables in real-time.
- The program should be able to autocorrect for inaccuracies during use.

Non-functional requirements

- The program should be able to perform the statistical calculations accurately and interpret user selections.
- Users should be able to save and load the digitised nomograms through a common file format.

Design

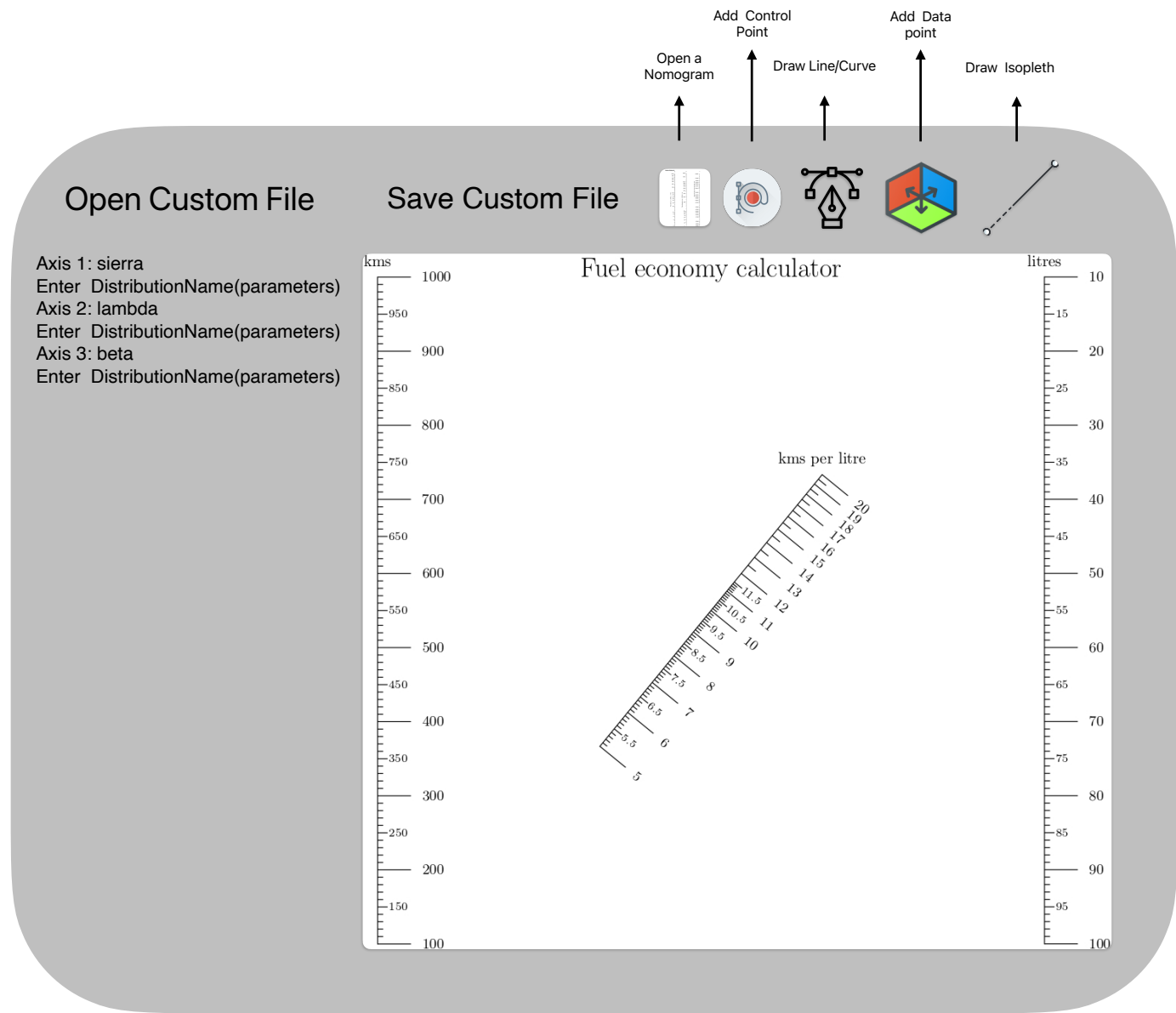


Figure 3: application wireframe

Implementation

- The application was developed in Python 3, using a combination of different libraries, such as Scipy for fitting data points and statistics, Bezier package for curves, and Regular Expressions for Distributions.

DEMO

Evaluation

User studies with university students to understand the effectiveness of the application.

Participant # / Axis	First axis (height)	Second axis(BMI)	Third axis(weight)
Participant 1	4	4	4
Participant 2	6	6	4
Participant 3	4	5	4
Participant 4	4	4	4
Participant 5	4	4	4
Participant 6	4	4	4
Participant 7	4	4	4
Participant 8	4	4	4
Participant 9	4	4	4

Table 1: *The number of axis data points users had to add for each axis on the body mass nomogram*

Evaluation

What features or functionalities do you think could be improved or added to enhance the application's usability?

Add a way to see the saved distributions

make the targets for the isopleth bigger so it is easier to interact with.

Less laggy, UI could be a little clearer (lots of overlap at some points)

The red text overlaps with the red line which can make it a bit difficult to read

adding multiple points of the same kind without clicking again the button

Multiple selection of axis points. Possibly a nicer looking interface

Potentially more easily identifiable images.

Maybe easier to move and control the points

isopleth to not go offscreen

spacing out the values given by the isopleth so they are easier to read

Table 2: qualitative results from the user evaluation

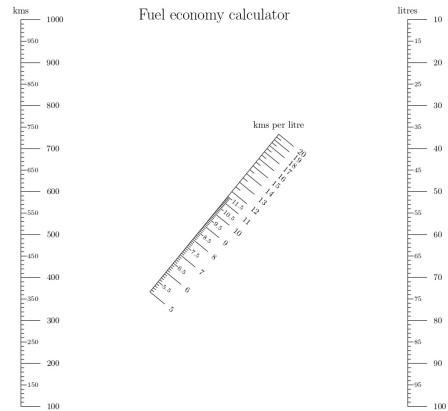
Evaluation

Is this the first time you have heard of what a nomogram is?	How well were you able to create an accurate representation of the nomogram on the canvas?	How many axis measurements/yellow points did you need to add to get an accurate representation of the first axis (height)?	How many axis measurements did you need to add to get an accurate representation of the second axis(BMI)?	How many axis measurements did you need to add to get an accurate representation of the third axis(weight)?	If you had any other difficulties while creating a digital representation of the nomogram, please explain them here.	Can you identify the probability density or mass function on the axis?	How well were you able to interact with the isopleth and see statistical information?	Do you see yourself using nomograms to create interactive visualisations of calculations you make frequently?	Which calculations do you see nomograms useful to make?
No	Somewhat well	4	4	4	Just remembering the instructions and commands, since it is the first time using the application	Yes	Somewhat well	No	Probability functions
Yes	Extremely well	6	6	4	Suggestion: allow the buttons to be toggled on or off	Yes	Somewhat well	Yes	fuel efficiency for cars
Yes	Somewhat well	4	5	4	The keyboard shortcuts weren't working well, but I realised that's because it was a Mac keyboard. There was a lot of button pressing repetition	Yes	Somewhat well	Yes	Probability, statistical analysis equations
Yes	Somewhat well	4	4	4	Remembering the shortcuts was difficult (though this would ease with time). I think the pictures at the top could be made slightly more intuitive.	Yes	Somewhat well	No	I don't make frequent calculations
Yes	Somewhat well	4	4	4	would be nice to not have to click many times to add points of the same kind	Yes	Somewhat well	No	none
Yes	Extremely well	4	4	4	Sometimes assumed I could keep adding axis points without clicking the button again	Yes	Extremely well	Yes	Equations in experiments
Yes	Extremely well	4	4	4	Instructions initially were unclear, but otherwise functionality was easy.	Yes	Extremely well	No	Probabilities over continuous values.
Yes	Extremely well	4	4	4	Wasn't sure exactly what I was doing at first - I didn't know what a control point was and why I was putting them on the axis	Yes	Extremely well	Yes	Anything which requires me to identify a relationship between two variables.
Yes	Extremely well	4	4	4	N/A	Yes	Somewhat well	Yes	useful for math equations
Yes	Extremely well	I put 3 points, but I couldn't get an accurate representation	3 points	4	only issues stemmed from me not knowing nomograms	Yes	Somewhat well	Yes	Statistics and engineering calculations

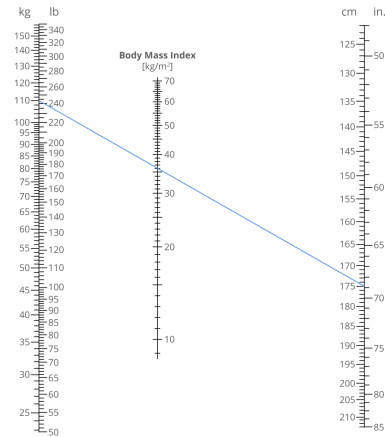
Table 2 showing the users opinion on the ease of use and future viability of the application

Evaluation

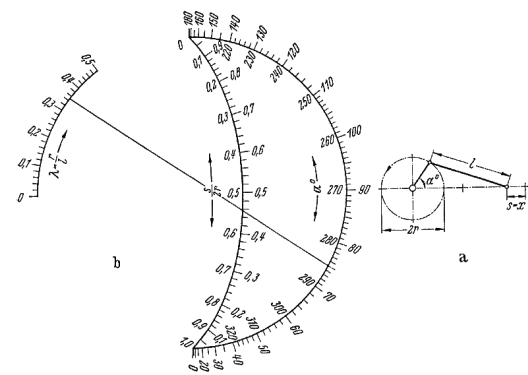
Axis Name	RMS Inaccuracy
Kilometres	2.252×10^{-7}
Litres of petrol	3.675×10^{-9}
Kilometres per litre	8.163×10^{-9}



Axis Name	RMS Inaccuracy
BMI	1.731×10^{-8}
Height	3.920×10^{-9}
Mass	1.550×10^{-7}



Axis Name	RMS Inaccuracy
λ	1.265×10^{-5}
s	4.538×10^{-4}
α	1.910×10^{-1}



Tables 4,5,6 showing the RMS inaccuracies

Conclusion and Future Work

- In conclusion, we have managed to develop an application that can create interactive visualizations of nomograms with probabilistic relationships.
- Improvements to the application could be made in:
 - 1) User interface and workflow
 - 2) Improvements in data fitting and importing custom datasets for probabilities
 - 3) Adding a custom interpreter for PyNomo
 - 4) More user evaluations in primary and secondary schools.