JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

Enhancing the decision-support capabilities of interactive multiobjective optimization with explainability

Lectio praecursoria

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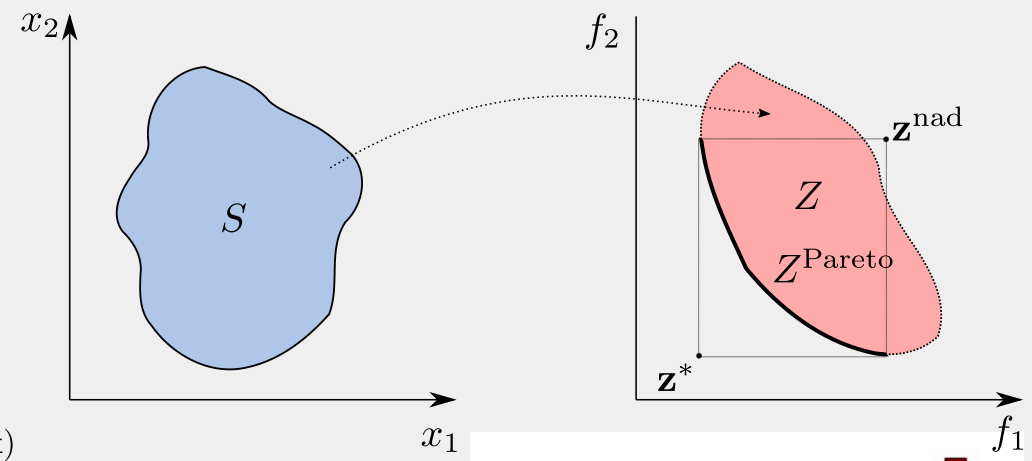
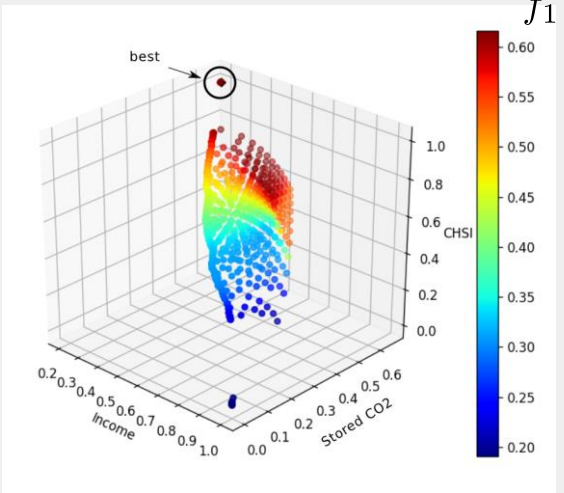
Problem: How can we best support decision makers from different problem domains find their best compromise solution to problems with multiple conflicting criteria?

How I would typically go about this

$$
\begin{aligned}
&\min\ f_1(\mathbf{x})\\
&\min\ f_2(\mathbf{x})\\
&\max\ f_3(\mathbf{x})\\
&\max\ f_4(\mathbf{x})\\
&\text{s.t. } g(\mathbf{x}) \le 0\\
&\qquad h(\mathbf{x}) = 0
\end{aligned}
$$

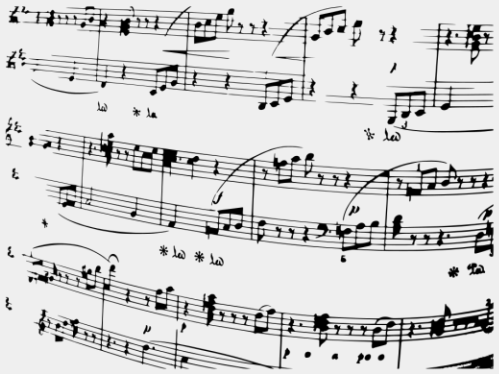


$$
\begin{aligned}
\min\quad & \alpha + \rho \sum_{i=1}^{k} \frac{f_i(\mathbf{x})}{z_i^{nad} - z_i^{\star\star}} \\
\text{s.t.}\quad & \frac{f_i(\mathbf{x}) - z_i^*}{z_i^{nad} - z_i^{\star\star}} - \alpha \le 0 && \forall i \in I^< \\
& \frac{f_i(\mathbf{x}) - \hat{z}_i}{z_i^{nad} - z_i^{\star\star}} - \alpha \le 0 && \forall i \in I^\le \\
& f_i(\mathbf{x}) - f_i(\mathbf{x_c}) \le 0 && \forall i \in I^< \cup I^\le \cup I^= \\
& f_i(\mathbf{x}) - \epsilon_i \le 0 && \forall i \in I^\ge \\
& \mathbf{x} \in S,
\end{aligned}
$$



$$
\max_{i=1,\ldots,k} \left[\frac{f_i(\mathbf{x}) - \bar{z}_i}{z_i^{\text{nad}} - (z_i^\star - \delta)} \right] + \rho \sum_{i=1}^{k} \frac{f_i(\mathbf{x})}{z_i^{\text{nad}} - (z_i^\star - \delta)}
$$

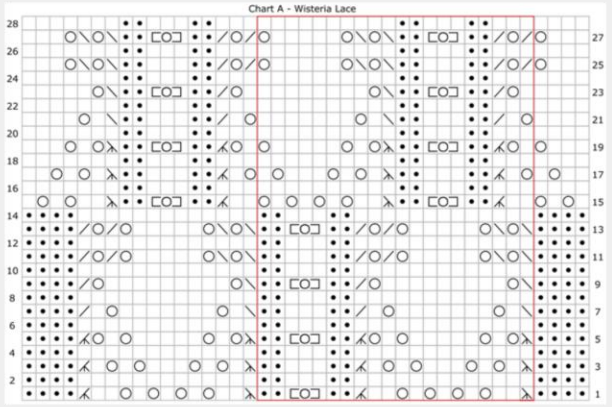
It is the language that is complicated here



خيار إعادة نتيجة أخذ ما, عل وقد دارت قادة اوروبا. وقد نتيجة التاريخ، ثم. أخذ لم لفرنسا بالتوقيع. فصل كرسي والنرويج و, بل خيار حالية الإحتفاظ نفس, مئات وحتى أدوات ولم أي. فعل وحتى عقبت ممثّلة أي.

كلّ سقطت الحكم تم. فهرست وأُسدل لمّ ما, تكبّد اليابان تم هذا. عن بعد فرنسية لهيمنة ويكيبيديا,, جهة مع لتقليعة وحلفاؤها, لم به، الإنزال استعملت ماليزيا،. حيث أدوات سليمان، وحلفاؤها بـ. أكثر إختار سبتمبر تم جهة.
جهة.

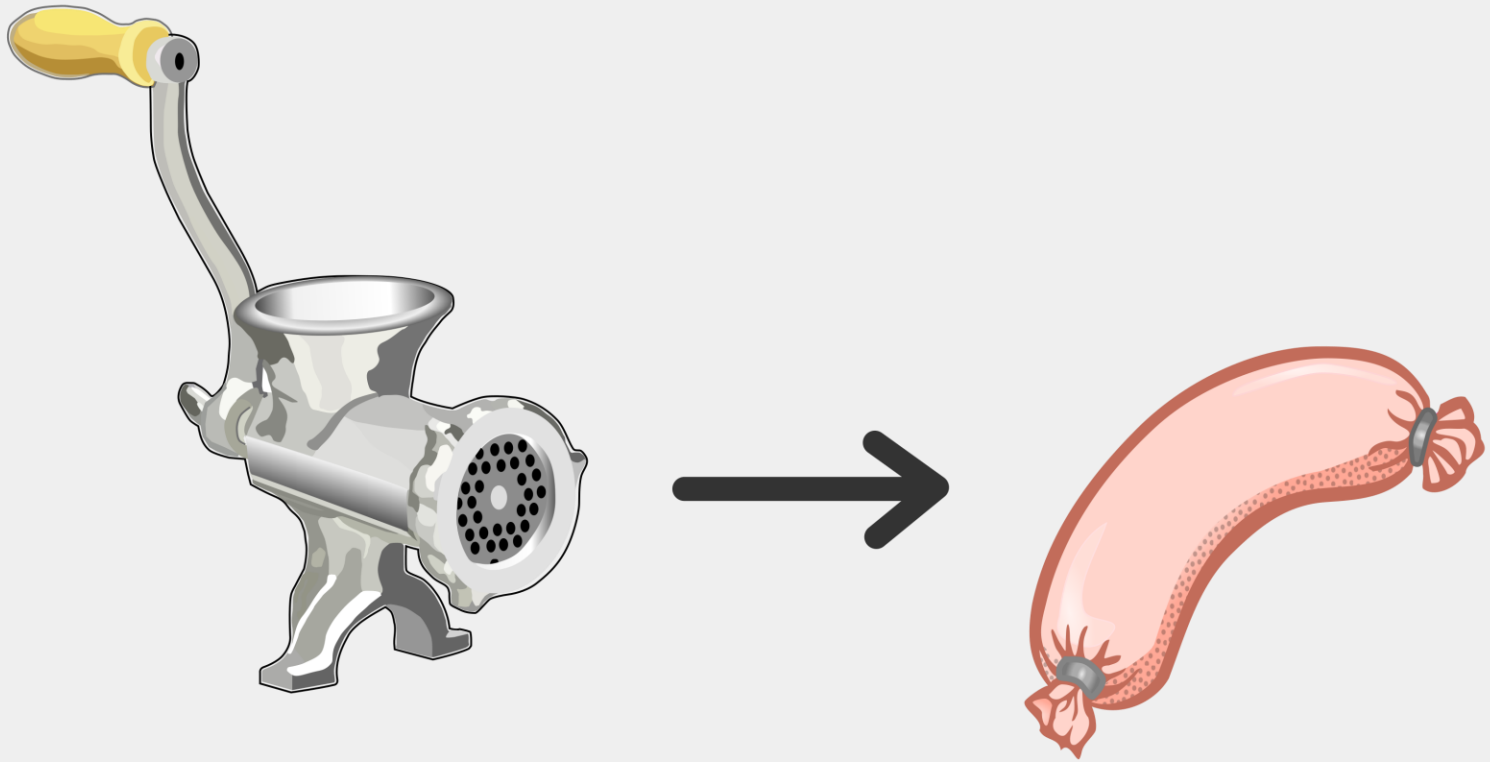
1. Nf3 Nf6 2. c4 g6 3. Nc3 Bg7 4. d4 O-O 5. Bf4 d5 6. Qb3 dxc4 7. Qxc4 c6 8. e4 Nbd7 9. Rd1 Nb6 10. Qc5 Bg4 11. Bg5 Na4 12. Qa3 Nxc3 13. bxc3 Nxe4 14. Bxe7 Qb6 15. Bc4 Nxc3 16. Bc5 Rfe8+ 17. Kf1 Be6 18. Bxb6 Bxc4+ 19. Kg1 Ne2+ 20. Kf1 Nxd4+ 21. Kg1 Ne2+ 22. Kf1 Nc3+ 23. Kg1 axb6 24. Qb4 Ra4 25. Qxb6 Nxd1 26. h3 Rxa2 27. Kh2 Nxf2 28. Re1 Rxe1 29. Qd8+ Bf8 30. Nxe1 Bd5 31. Nf3 Ne4 32. Qb8 b5 33. h4 h5 34. Ne5 Kg7 35. Kg1 Bc5+ 36. Kf1 Ng3+ 37. Ke1 Bb4+ 38. Kd1 Bb3+ 39. Kc1 Ne2+ 40. Kb1 Nc3+ 41. Kc1 Rc2# 0-1



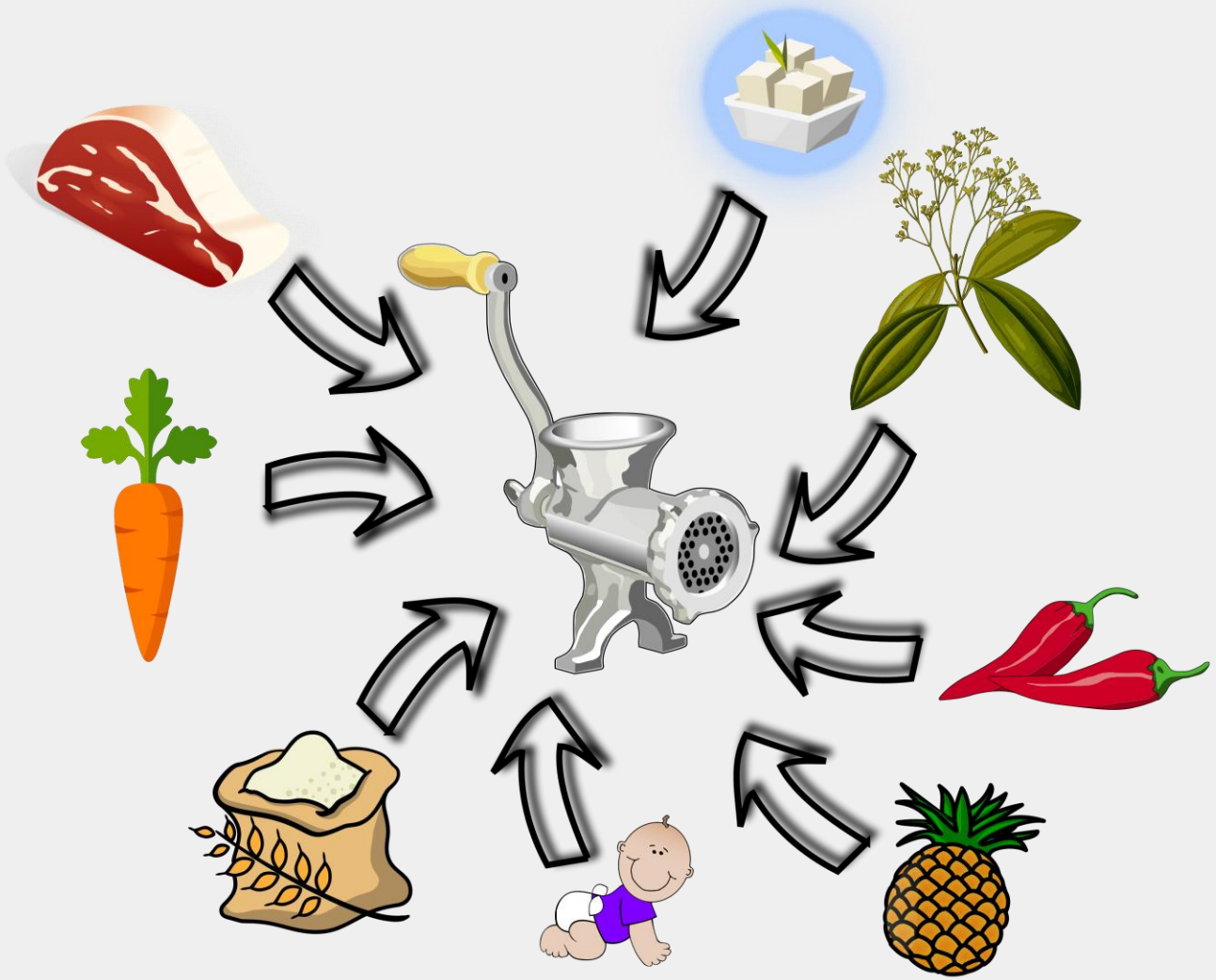
But what language to choose? What could we all be familiar with?

I want you to be able to appreciate the contributions of my thesis!

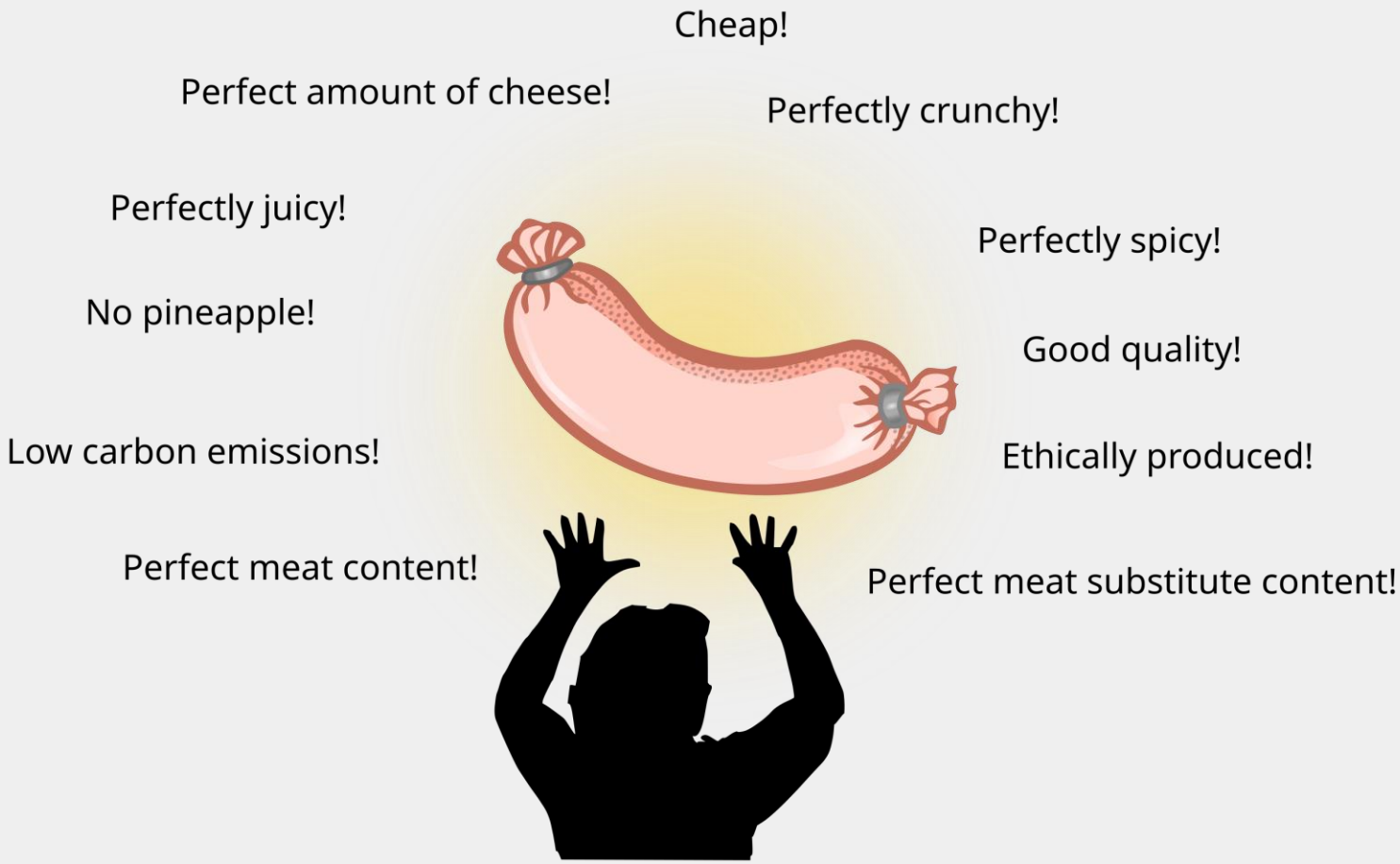
Sausages! Or rather, the process of making them.



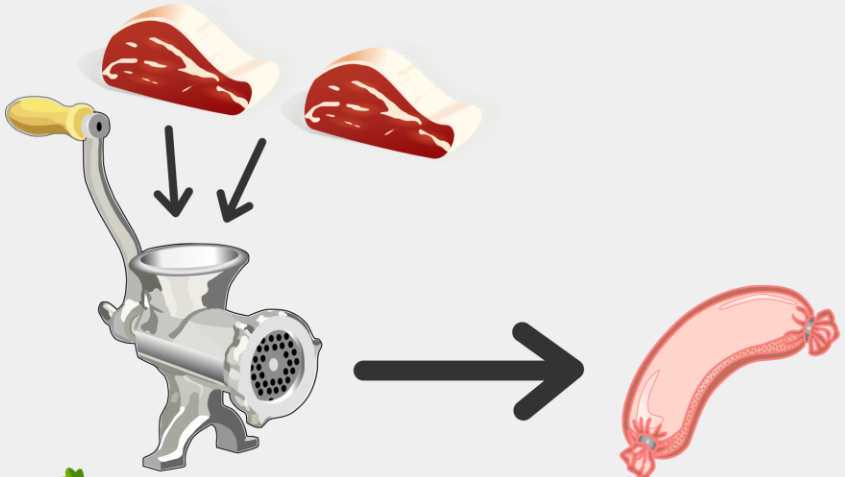
We can put anything in a grinder to make a sausage...



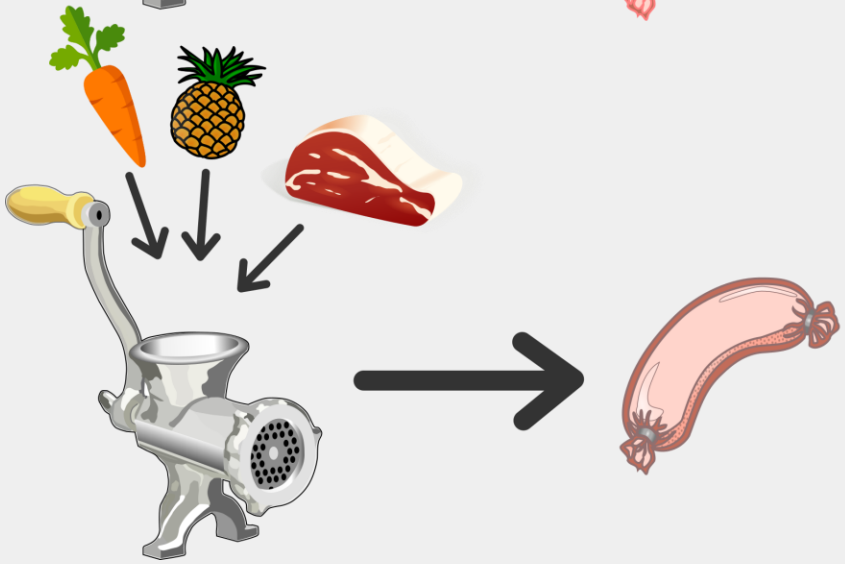
...and we all have our preferences when it comes to the *perfect* sausage...



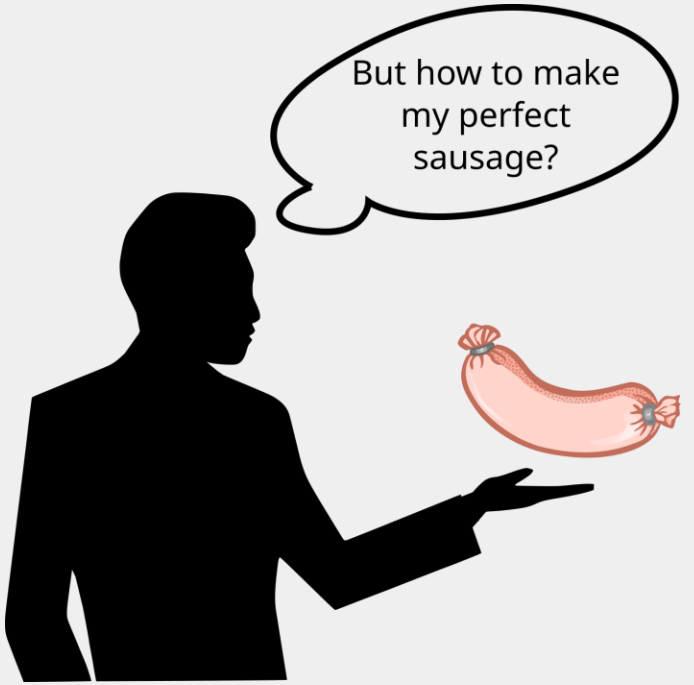
...but what to put into the grinder to get the perfect sausage?



Only using meat produces a very bad texture...



The texture is now nice, and the pineapple gives a nice zing, but I would still prefer a little bit more spice...

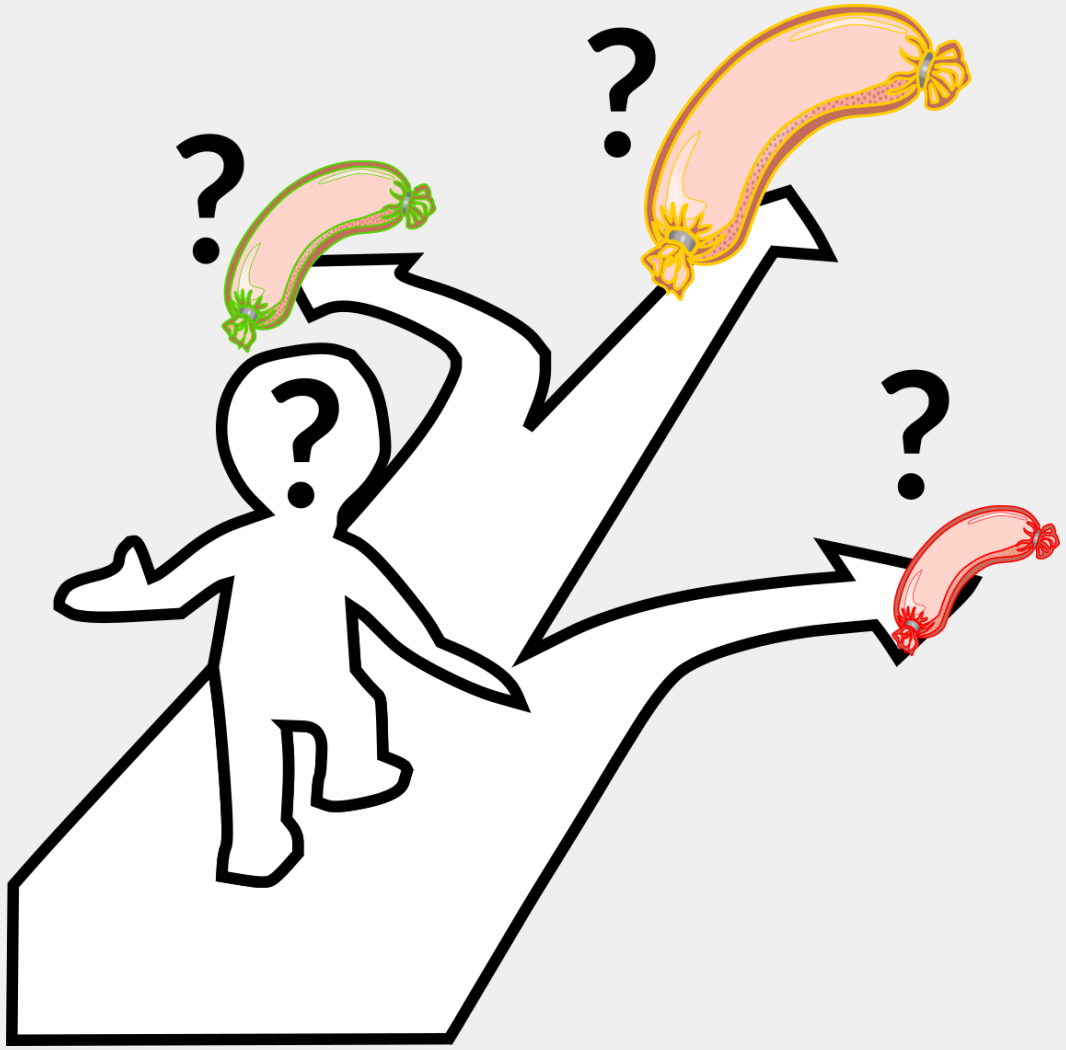


There are also trade-offs and constraints when it comes to making sausages

Constraints

Trade-offs

So are we just left to the mercy of guess work?



Instead of guessing, we can optimize!

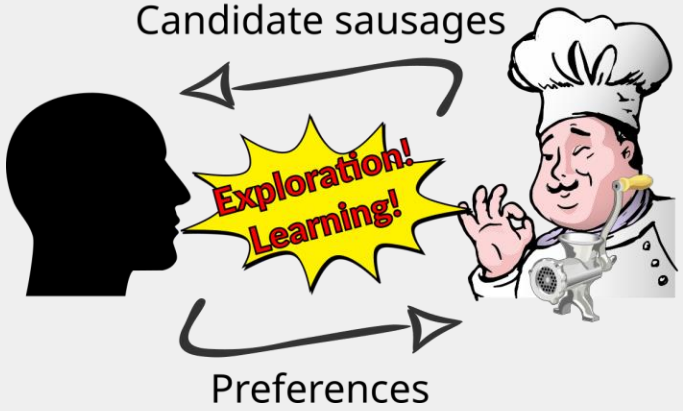
Pollution

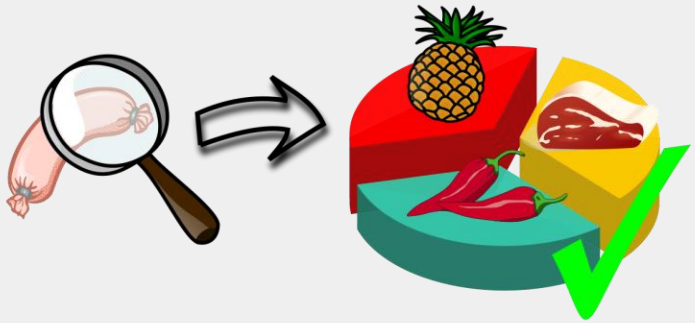
Spiciness

Healthiness

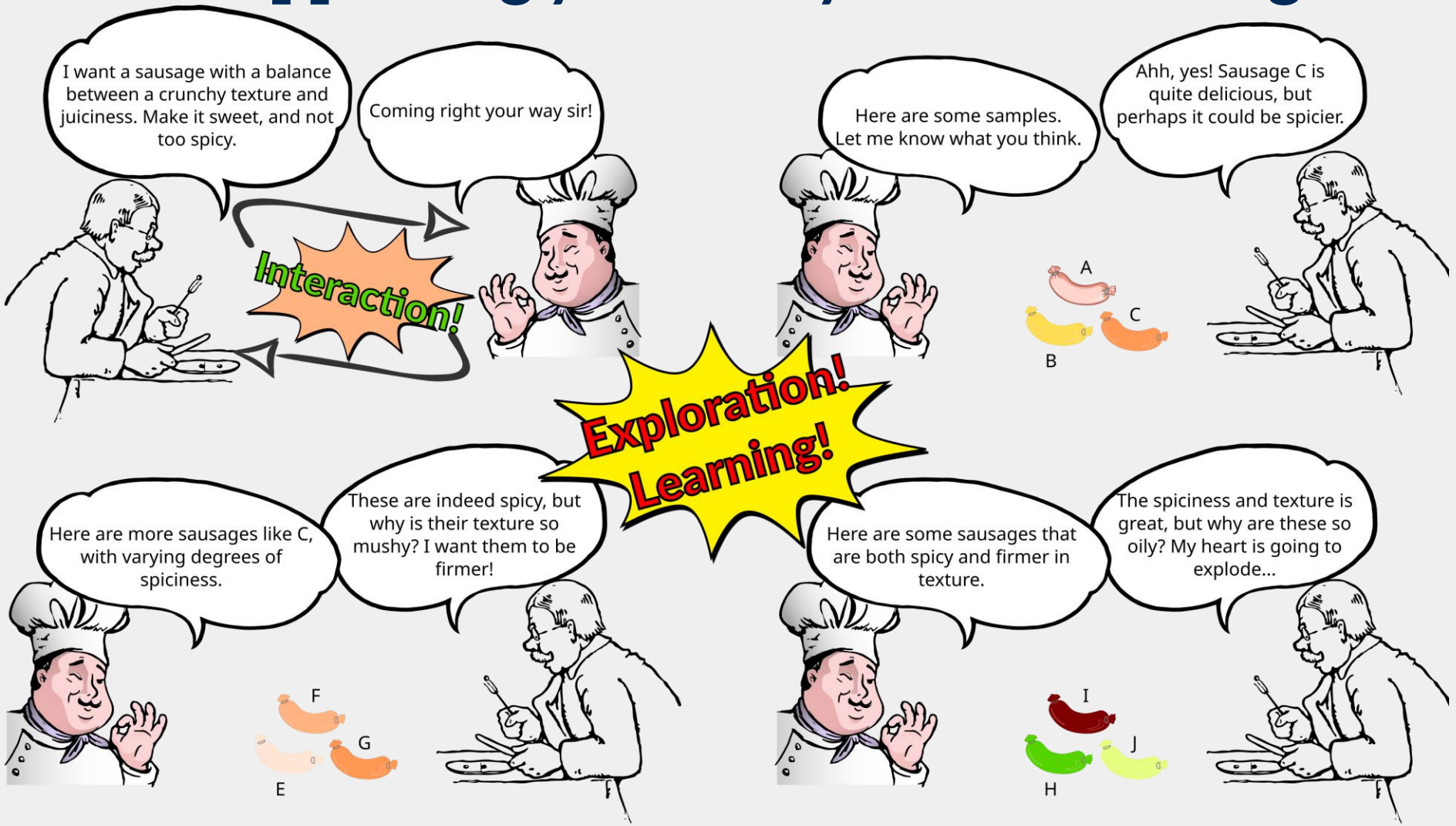
Price

Interactive multiobjective optimization

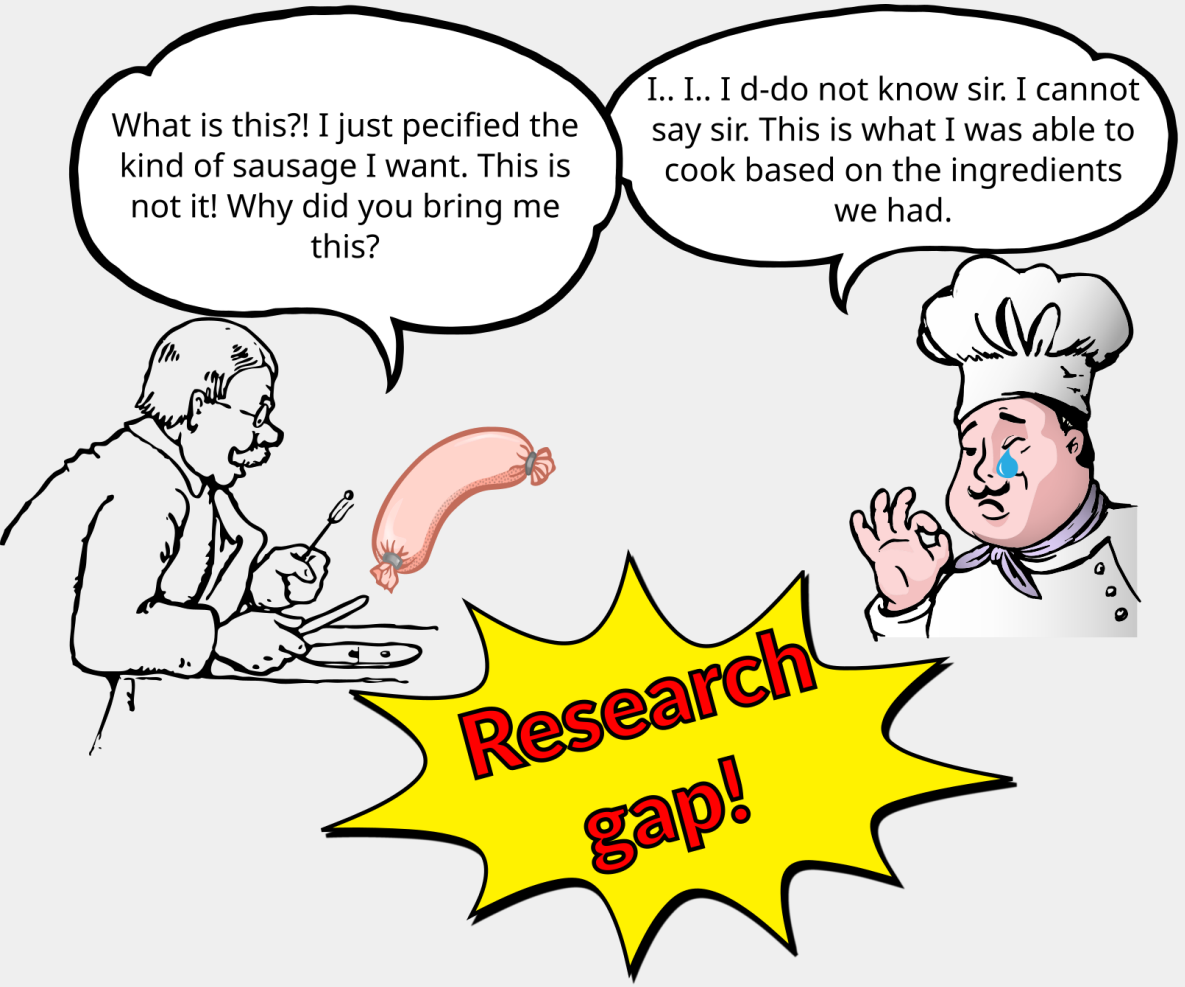


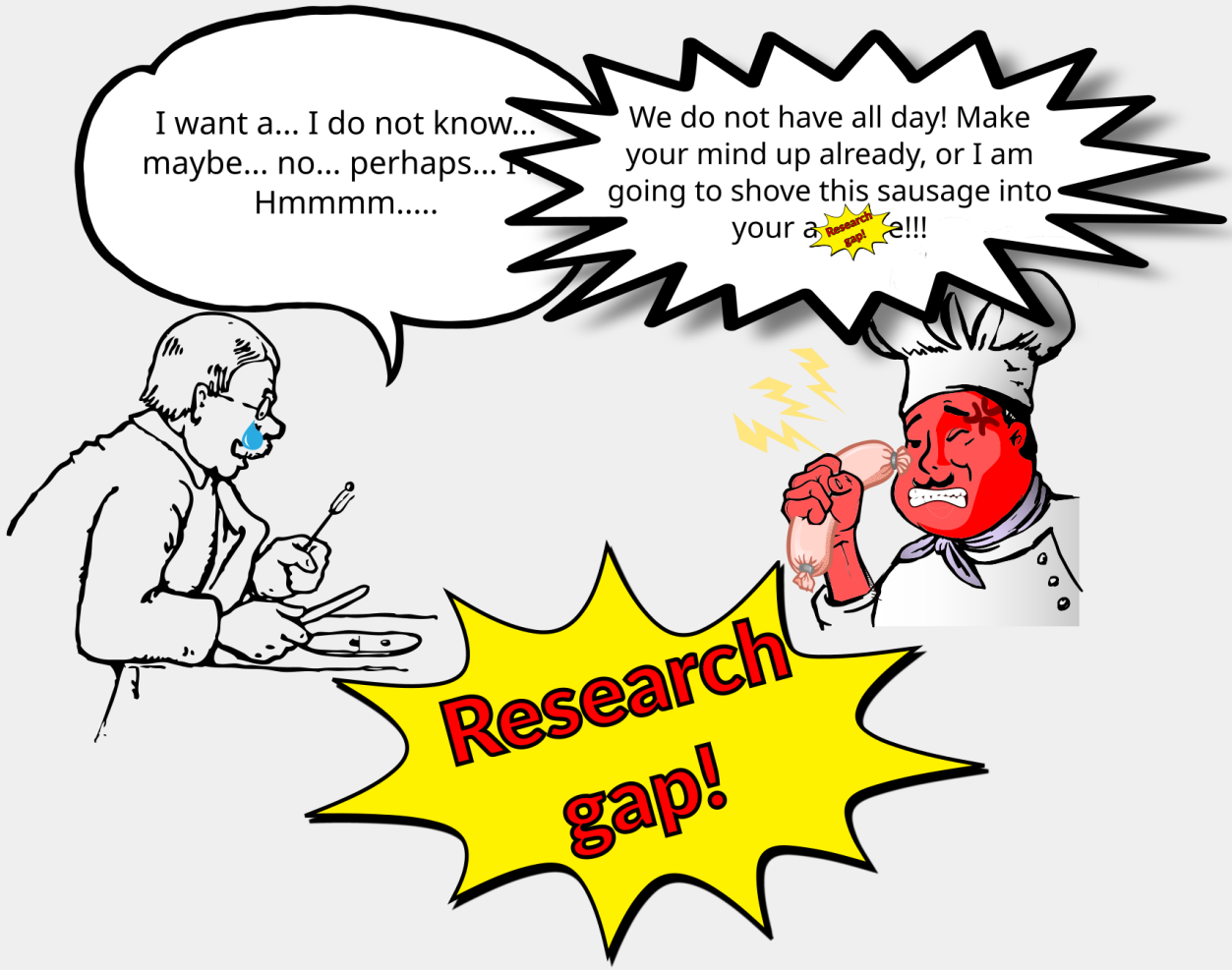


An interactive multiobjective optimization method is like a chef supporting you find your best sausage



But do chefs have the tools to meet our needs, and do we have the means to best express our preferences?



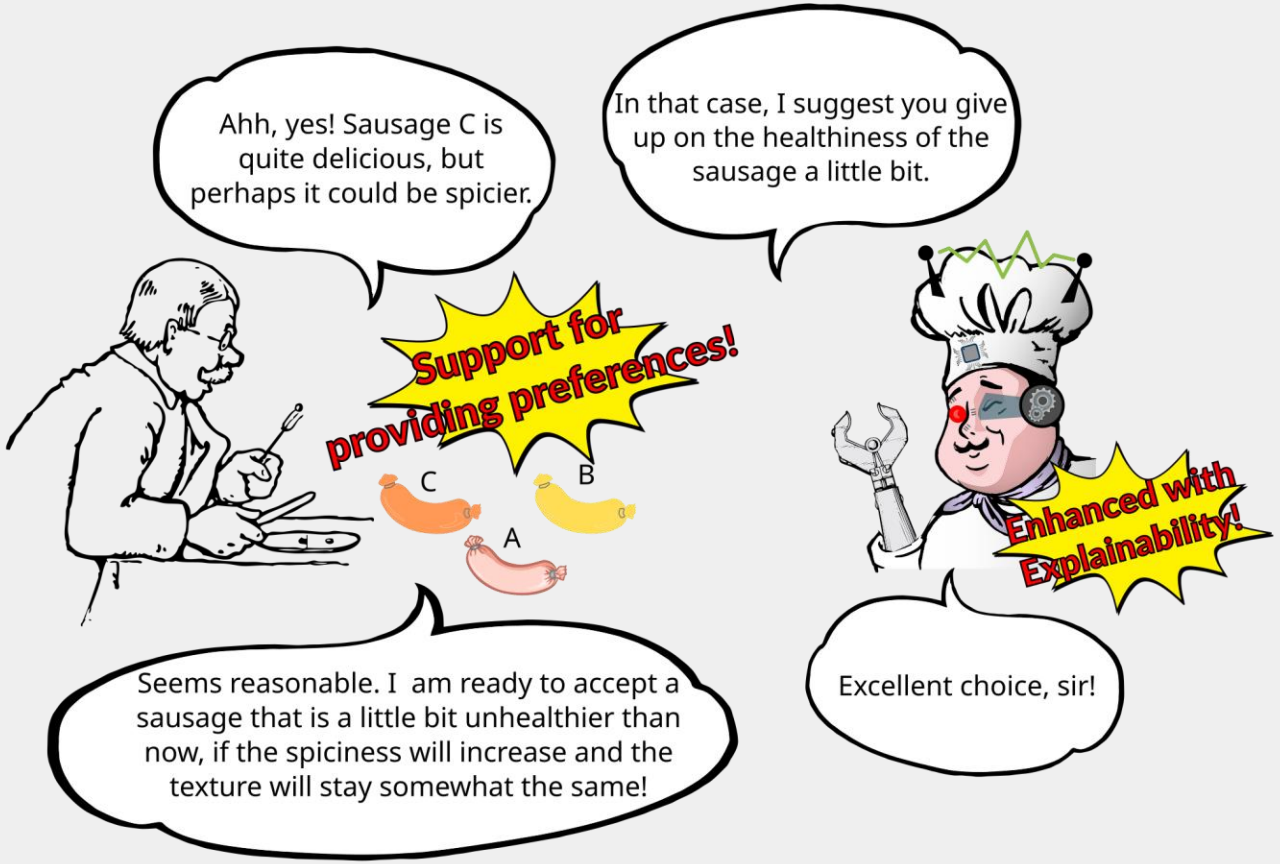


My thesis: A collection of four published articles

- In three of the articles, I have studied how we can improve interactive multiobjective optimization methods (chefs making us sausages on request) so that the decision maker (us or the customer wanting the sausages) can better express their preferences and understand why they get the kind of solutions (sausages) as they do.
  - I have approached these problems by leveraging the concept of so-called **explainability**.
- In one of the articles, I discuss a software framework for developing interactive multiobjective optimization methods.
  - You can think of this as a toolbox to train different kinds of chefs, giving them better customer service skills, but also make them more approachable, so that we can express our sausage preferences easier.

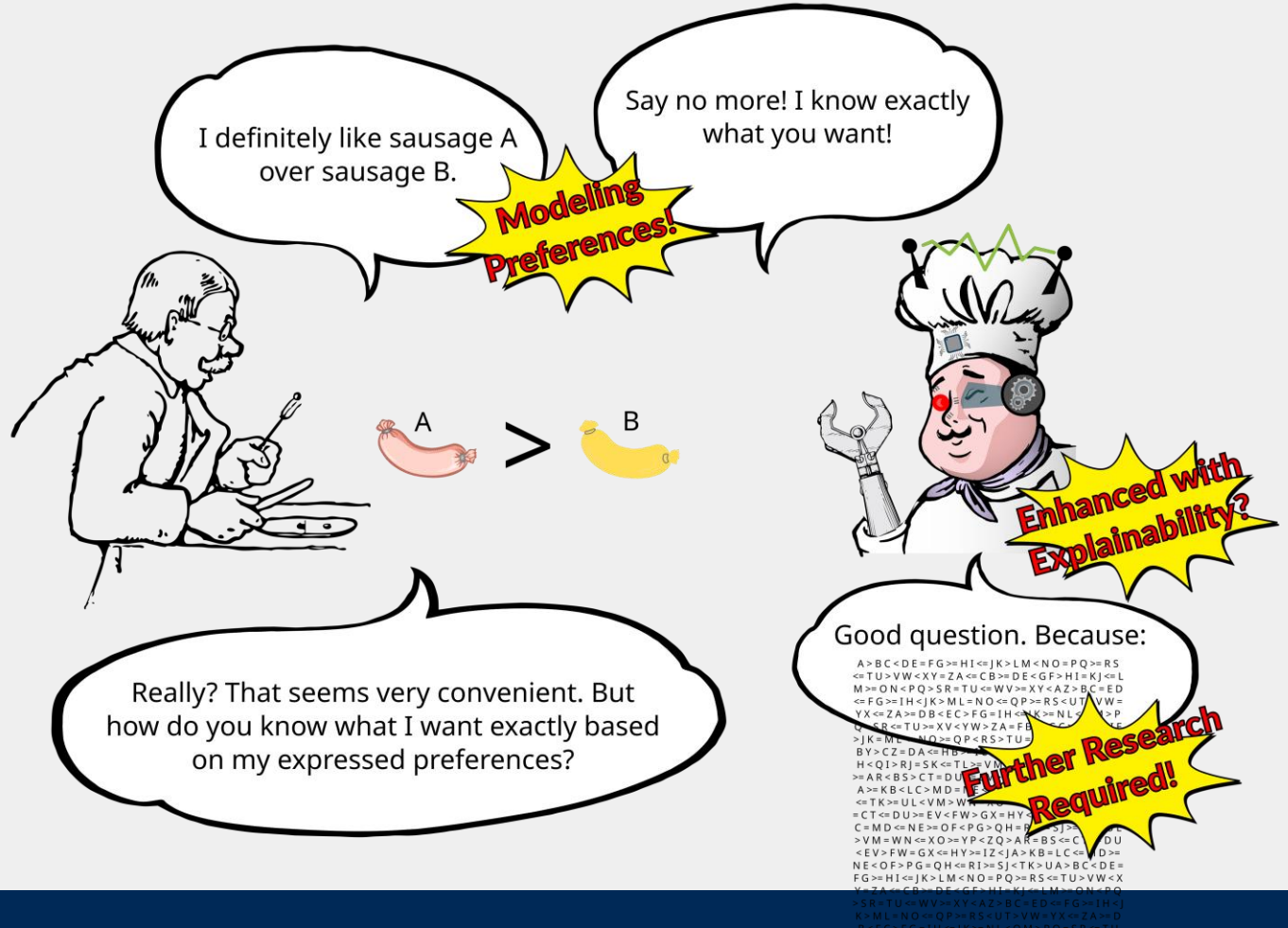
Article 1: Towards explainable interactive multiobjective optimization: R-XIMO

- Explainability has been used to enhance an interactive multiobjective optimization method to better support the decison maker in providing prefereneces, and understanding the connection of the preferences to the computed solutions.



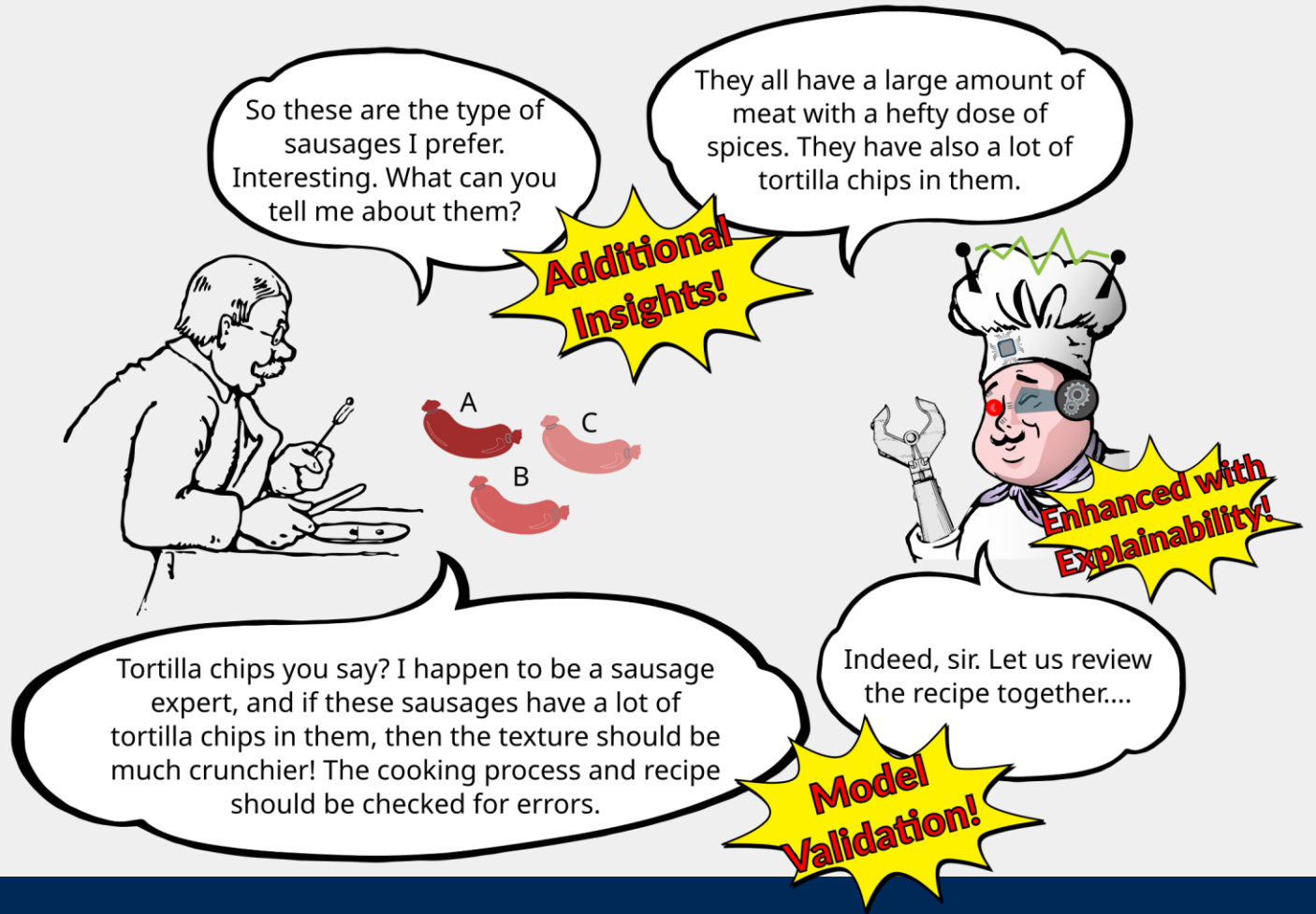
Article 2: Interactively learning the preferences of a decision maker in multiobjective optimization utilizing belief-rules

- A rule-based machine learning model has been used to learn the preferences of a decision maker through pair-wise comparisons. However, the explainability of the model requires further investigations.



Article 3: Exploring the explainable aspects and performance of a learnable evolutionary multiobjective optimization method

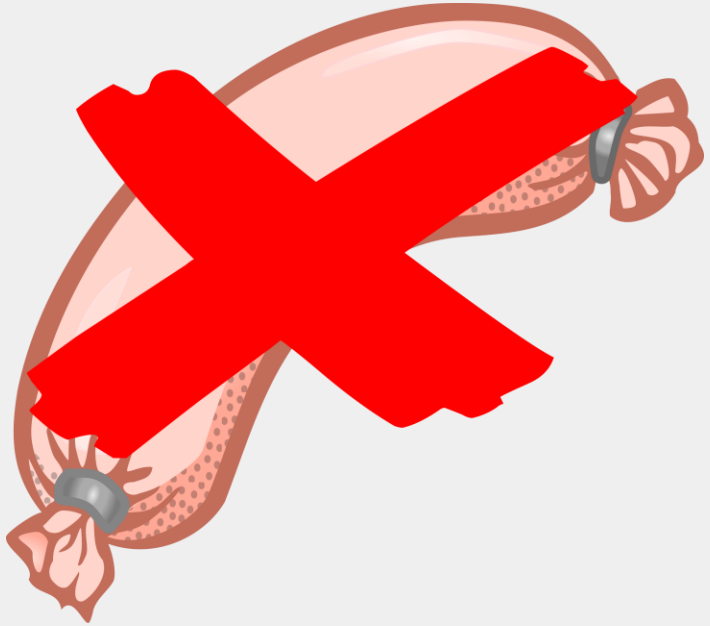
- Explainability has been utilized to provide deeper insights about preferred solutions. This can support the decision maker both in better understanding the solutions and the model of the problem.



Article 4: DESDEO: The modular and open source framework for interactive multiobjective optimization

- DESDEO, an open source software framework for interactive multiobjective optimization, has been developed. It has played a key role in the research and development of Articles 1-3. DESDEO also offers tools and means to research and implement further methods with explainability.

Confession: I do not actually study sausages



The methods and ideas proposed in my thesis can be applied in many different applications

The research in my thesis can help decision makers from different problem domains find their best compromise solution to problems with multiple conflicting criteria.

Most importantly, my research can make the process explainable and transparent.

The best compromise is the one we can understand and justify to others and ourselves!