Retabit

SUPTM 2024 - 2nd Conference on Future Challenges in Sustainable Urban Planning & Territorial Management

A Multidimensional Approach to enhance sustainable Building Renovation planning

The RETABIT Project

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Green Deal
Fit for 55
Renovation Wave

Europe climate-neutral
(net zero emissions) by 2050

~75% of EU buildings
are not energy efficient

only **1%** are energy-efficient
renovated every year

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Building retrofitting programs

Planning renovation based on **sustainability**
(environmental, social, and economic aspects)

Multi-domain data **integration**
(Urban planners, domain experts and society at large)

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(environmental, social, and economic aspects)

Collaborative Planning

Participatory and holistic procedures leading to an integrated planning process among decision-makers.

Challenges:

- Multiple statements and objectives
- Dynamic and complex context
- Data uncertainty
- Issues related to the participatory actors

Inefficient, time-consuming, and costly planning process for acquiring and analysing information

Current tools and methods to alleviate challenges

Key Performance Indicators (KPIs)

Multi-Criteria Decision Method (MCDM)

Artificial Intelligence (AI)

RETABIT is co-financed by the Spanish national research plan (2021-24)

The goal of the project is to develop a **geo-spatial data driven platform** for Catalonia which will facilitate **decision-making processes** in **large-scale residential** building retrofitting programs to:

1. Explore urban areas and evaluate their renovation potential based on building classification and sustainability indicators
2. Create and assess renovation plans based on multidimensional indicators
3. To follow up the impact of the implemented renovation plans over time

Problem: The planners need to define a route for retrofitting based on sustainability aspects → They need to contrast their knowledge about the building stock with real data.

Retabit solution: Explore urban areas and evaluate their renovation potential based on building classification. The platform includes 16sustainability indicators encompassed within environmental, economic and social aspects of sustainability.

Barriers: Need to read, understand, select and make connections

Method

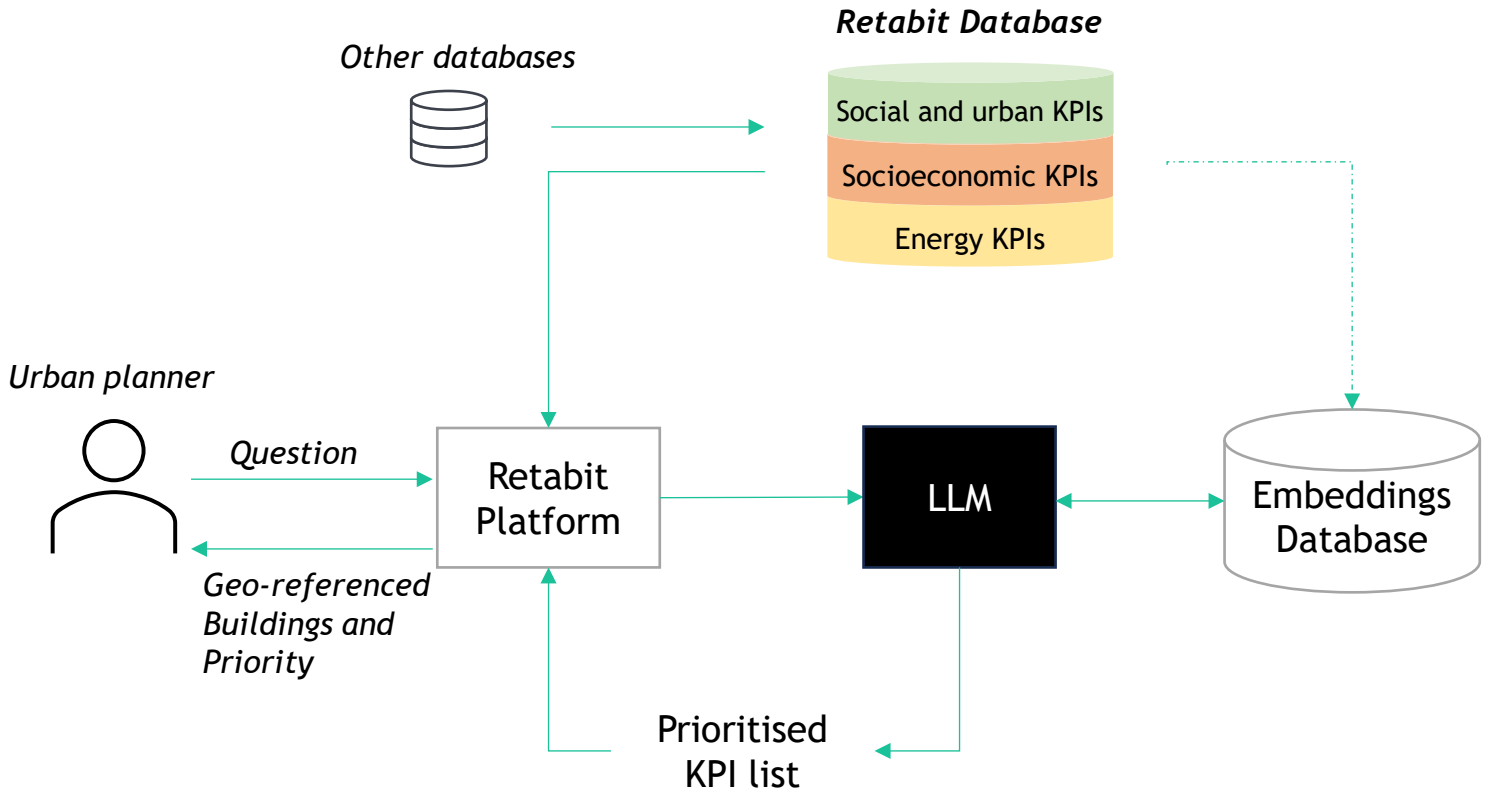
Help the user to select and prioritise KPIs according to their needs

MCA-LLM method developed for Retabit

Key Performance Indicators (KPIs)

Multi-Criteria Analysis Method (MCA)

Large Language Models (LLM)



Embeddings

Numerical representations of natural language text, helping computers understand relationship between ideas.

They map text onto a vector representation within a high-dimensional space, with each dimension capturing a specific aspect of the input.

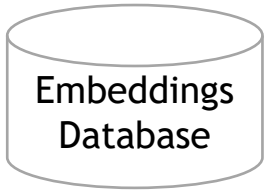
Creation of the KPIs embeddings database

Why?

KPIs were previously prepared to be correctly transformed into embeddings by the LLM to address the user question.

How?

By the inclusion of the following text inputs to the KPI:



a) KPI ID + name

b) KPI definition according to a literature review

c) KPI definition of the relationships with other KPIs

d) Directions of all definitions

Embeddings

Numerical representations of natural language text, helping computers understand relationship between ideas.

They map text onto a vector representation within a high-dimensional space, with each dimension capturing a specific aspect of the input.

a) "KPI1 Energy renovated residential buildings"

b) "Energy renovated have been renovated considering energy efficiency measures"

c) Additional descriptions:

   i. "Energy renovated have lower **demand of energy**"

   ii. "Energy renovated potentially have lower **consumption of energy**"

   iii. "Energy renovated are likely to have improved energy performance making them potentially more suitable for the promotion of energy **self-consumption**"

   iv. …

d) Direction

   i. "Energy renovated have lower demand of energy"

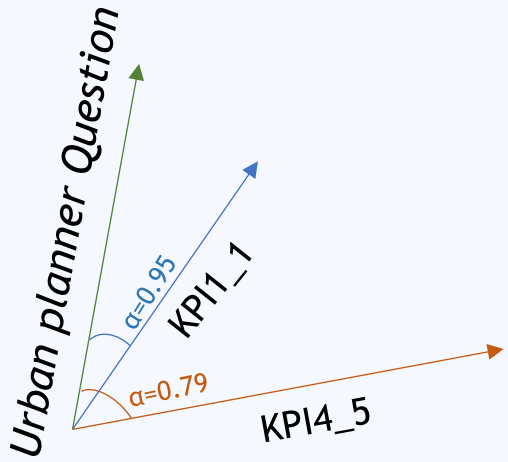
   i. "**Non-Energy renovated** potentially have higher demand of energy"

   ii. …

Embeddings Database (16 KPIs x nº of definitions x 2 Directions)

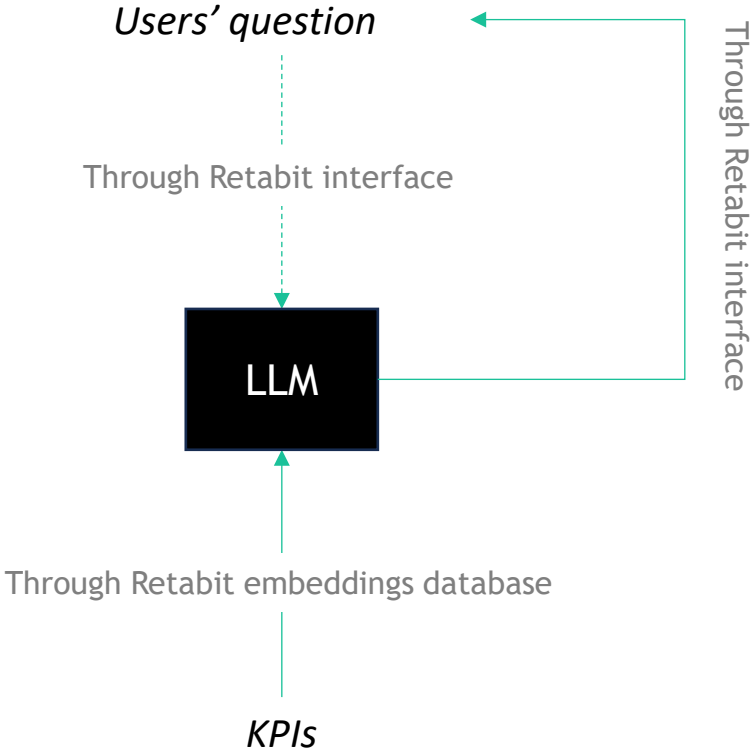
Cosine Similarity

Measure to calculate the similarity between two vectors different to zero that are within a dimensional space.



Threshold = 0.8

Identification



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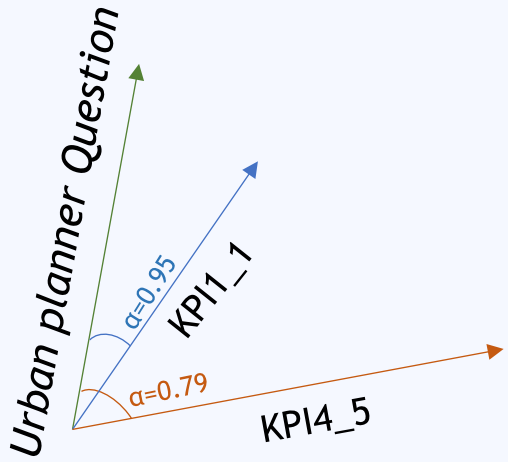

Threshold = 0.8

Prioritisation

$$Building\ Priority = \sum_i (KPI_i \times W_i) \longrightarrow W_i = \frac{\alpha_i - Min(\alpha)}{Max(\alpha) - Min(\alpha)}$$

Where are the areas that contain a population with income levels below the average and present a tense housing market and an accelerated increase in rental or purchase prices?

KPI	Title	Direction	Sim	Normalized Weight
20	Median household income	-	0.871	
19	Population with income below 60% of the average	+	0.866	¿?
21	Average annual price of renting a home compared to gross disposable family income	+	0.859	
22	House Price	+	0.848	

$$W_{KPI19} = \frac{0.866-0.8}{0.871-0.8} = 0.878 \longrightarrow Normalized\ W_{KPI19} = \frac{0,878}{\sum W_i}$$

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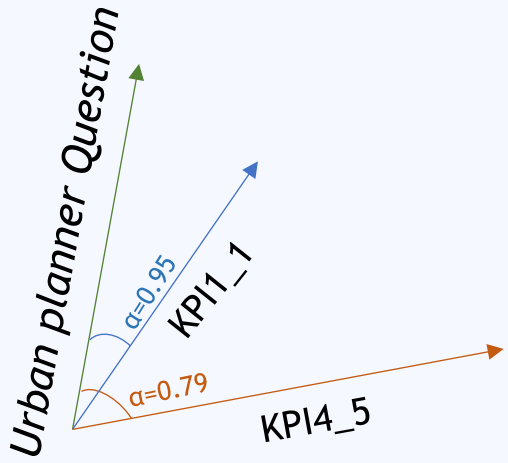

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KPI	Title	Direction	Sim	Normalized Weight
20	Median household income	-	0.871	0.33
19	Population with income below 60% of the average	+	0.866	0.29
21	Average annual price of renting a home compared to gross disposable family income	+	0.859	0.23
22	House Price	+	0.848	0.15

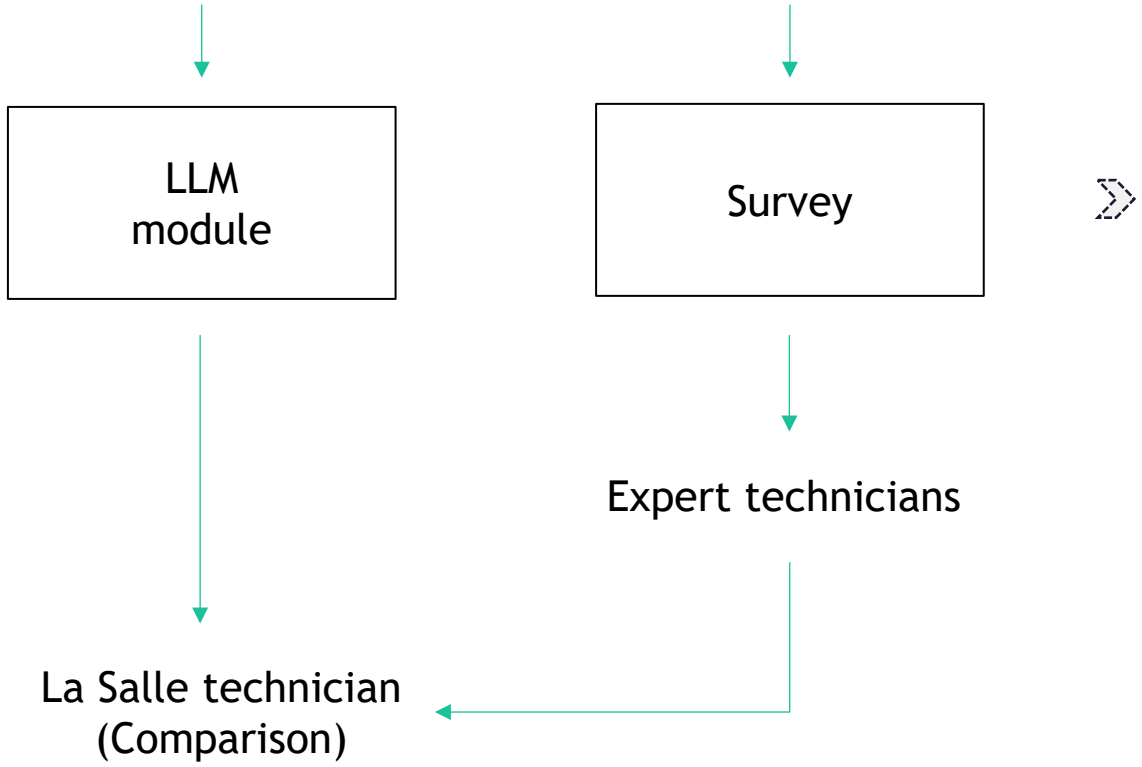
$$Building\ Priority = \sum_i (KPI_i \times W_i)$$ ⇨ Georeferenced representation

Retabit database normalised values per building


Todos
de 0 a 0.5
de 0.5 a 1
de 1 a 1.5
de 1.5 a 2
de 2 a 2.5
de 2.5 a 3
de 3 a 3.5
de 3.5 a 4

Validation Process

4 Up Questions from the *Spanish Law 11/2022*



- ***Summary:*** Survey goal and needs
- ***Information table:***
  - KPI ID
  - KPI name
  - KPI Definition
  - KPI measurement units
- ***Platform access:*** Test environment link
- **Questionnaire:** 4 questions → 5 KPIs ordered by priority.

Selected KPIs (ID + Name)	Priority (1-5)
Where are the areas that contain a population with income levels below the average and present a tense housing market and an accelerated increase in rental or purchase prices?	
Where are the areas containing population with income levels below the average and presenting architectural or urban degradation or housing, energy efficiency or accessibility deficits?	
Where are the areas that contain population with income levels lower than the average and present insufficient public facilities or services or environmental degradation?	
Where are the areas that contain people with income levels below the average and show increased exposure to the effects of climate change, low air and water quality, high noise pollution, and a lack of green spaces or climate shelters?	

Results

Urban Planner Question	Number of agreed KPIs between all respondents	Number of agreed KPIs between all respondents and the LLM	Median number of matching KPIs between each respondent and the LLM
UpQ1	1	1	2,5
UpQ2	1	1	3,8
UpQ3	2	2	3,2
UpQ4	3	3	3

Consensus

Higher coincidence by respondent

Results

Urban Planner Question	Number of agreed prioritized KPIs between all respondents	Number of agreed prioritized KPIs between all respondents and the LLM	Median number of agreed prioritized KPIs between each respondent and the LLM
UpQ1	0	0	1,2
UpQ2	0	0	0,6
UpQ3	0	0	1,4
UpQ4	0	0	0

Lack of consensus

Higher coincidence by respondent

Conclusions

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MCA-LLM tackles multi-domain evaluation, offering adaptable outputs.

- The LLM selection of KPIs accommodates diverse technician knowledge, offering a comprehensive solution.
- Adequate alignment with the choices of the experts, yet achieving complete consensus is challenging.
- MCA-LLM method could offer new proving beneficial in the analysis.

The main limitation lies in the common prioritization of the KPIs.

- The prioritisation process requires further refinement.
- Complexity of automatic generation of similarity values.

Need to expand the survey sample.

- Broader training.

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If you would like more information, pelase visit ww.retabit.es, or contact us at info@retabit.es

Thanks for your attention!

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