

Science of Making Hard Decisions



@ Liberty Bar, Cork



Cemal Ozturk, PhD

Who am I ?

***Project Coordinator
Lecturer
Research Scientist
Industrial Engineer***



2014-

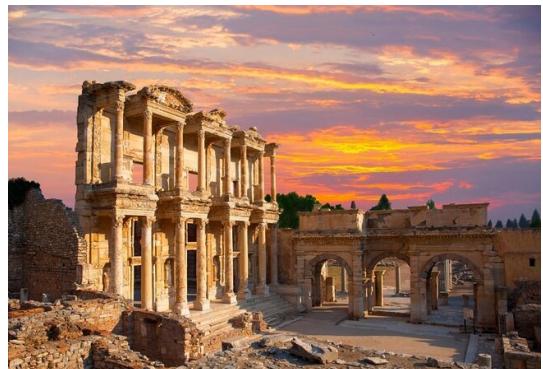


Collins Aerospace
An RTX Business



UCC

Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland

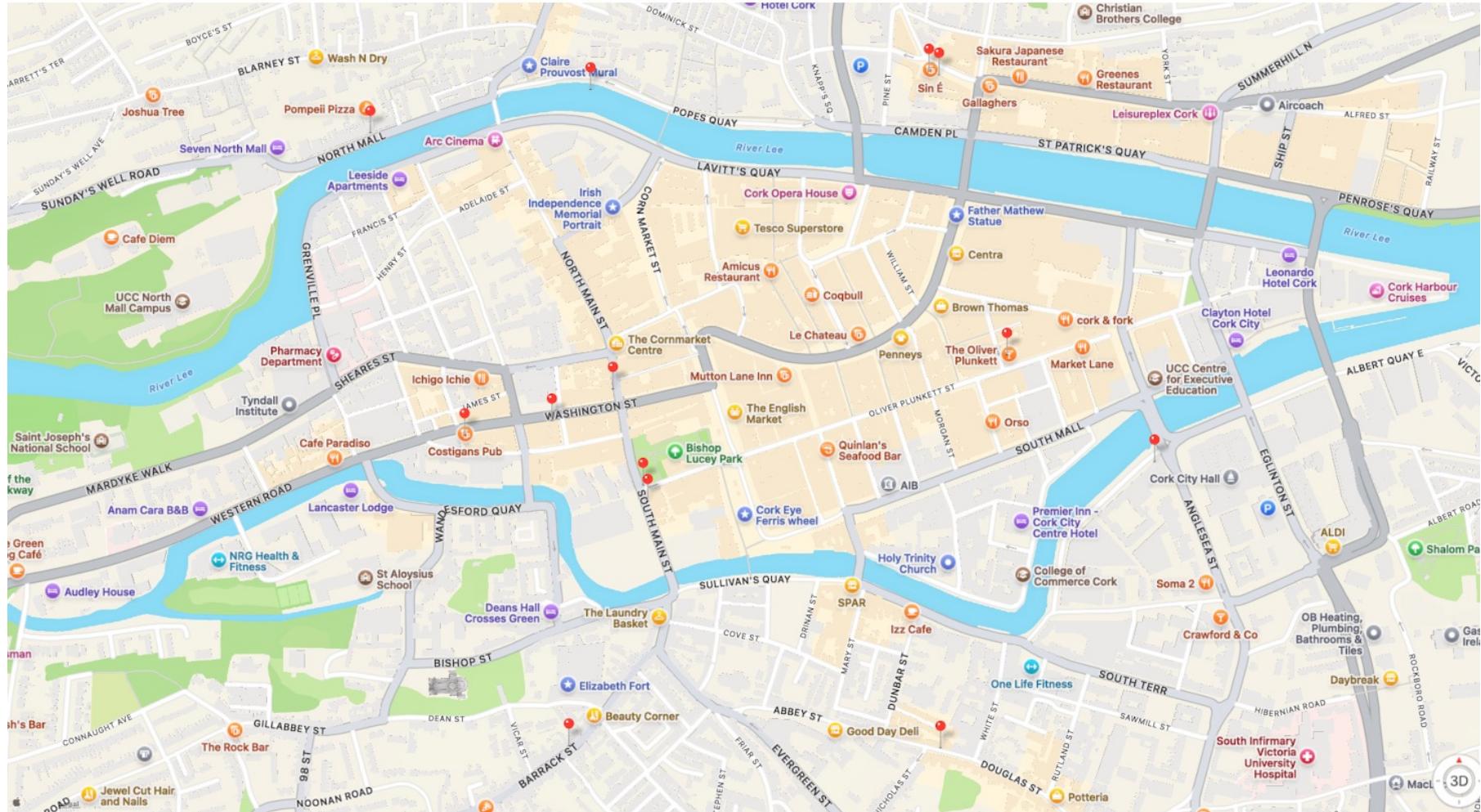


1980-2014



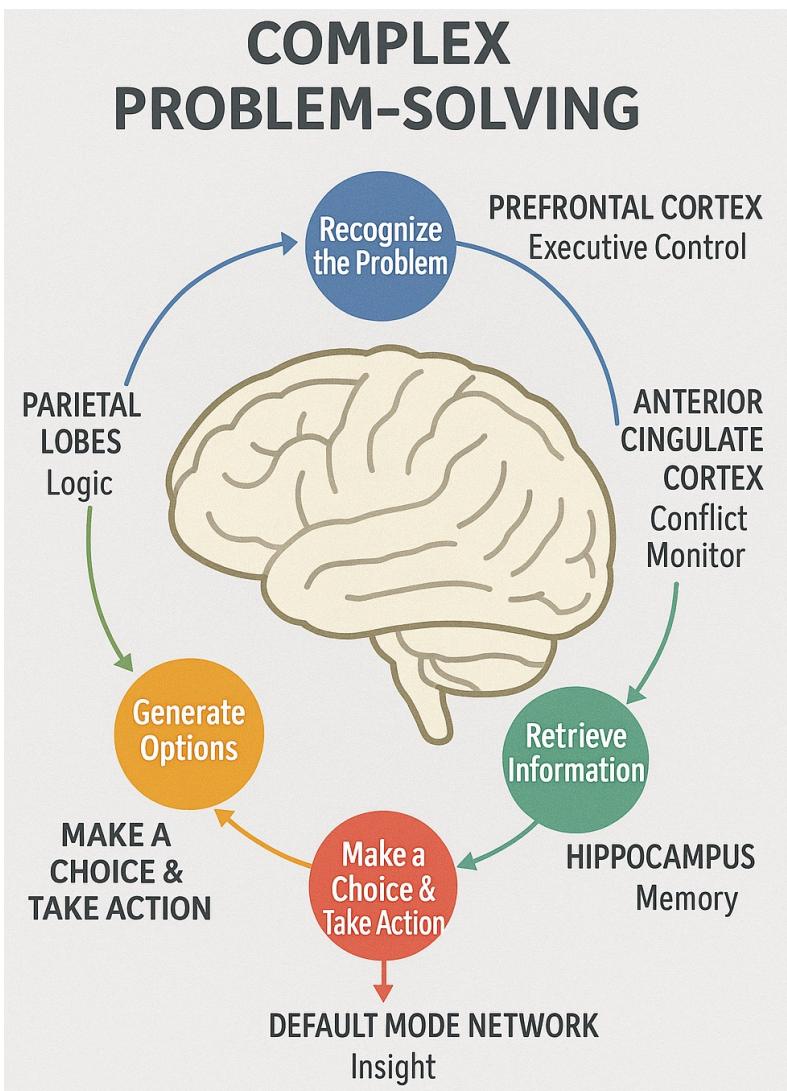
jsbir Sentetik

Pub Crawl at Cork with the shortest tour



Liberty bar | Dwyers of Cork | Costigans Pub | Franciscan Well | Tom Barry's | Sine E | An Spailpin Fanach | The Oval | Corner House | Charlies Bar | Fionbarra Bar | The Oliver Plunkett

How does our brain solve this ?



1. Recognize the Problem

(PFC, sensory areas): Identify what's wrong or what needs solving

2. Retrieve Information

(Hippocampus): Pull related memories, examples, or concepts

3. Generate Options

(PFC + DMN): Imagine potential solutions or strategies

4. Evaluate Options

(ACC + PFC): Compare tradeoffs, risks, rewards

5. Make a Choice & Take Action

(Motor Cortex): Send commands to act or decide

6. Reflect and Learn

(PFC + Hippocampus): Store results for next time



Pub Crawl at Cork starting from Liberty

Any suggestion ?

Liberty bar -- Dwyers of Cork -- Costigans Pub -- Franciscan Well -- Tom Barry's -- Sine E -- An Spailpin Fanach -- The Oval Corner House -- Charlies Bar -- Fionbarra Bar -- The Oliver Plunkett **Over 4 km !**

How many alternative pub crawl routes ?

Pub 1 (Start)	Pub 2	Pub 3	Pub 4	Pub 5	Pub 6	Pub 7	Pub 8	Pub 9	Pub 10	Pub 11	Pub 12
The Liberty	11	10	9	8	7	6	5	4	3	2	1

$11 \times 10 \times 9 \times 8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 11! = 39,916,800$ solutions

if Liberty to Costigans
distance is the same as
Costigans to Liberty ?

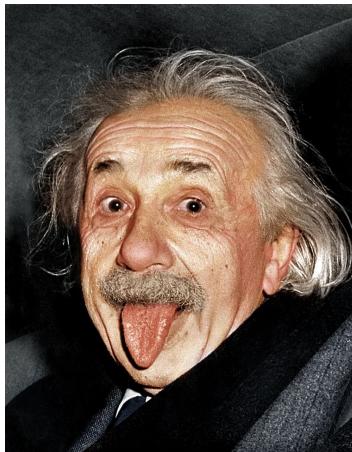
$$11!/2$$

if we have any
number ,n, pubs ?

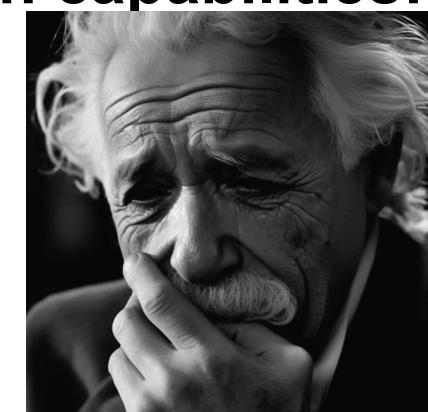
$$(n-1)!/2$$

Can Einstein find the best ever tour ?

1. **Recognize Problem**
 2. **Retrieve Information**
 3. **Generate Options**
 4. **Evaluate Options**
 5. **Make a Choice & Take Action**
 6. **Reflect and Learn**
- the pub



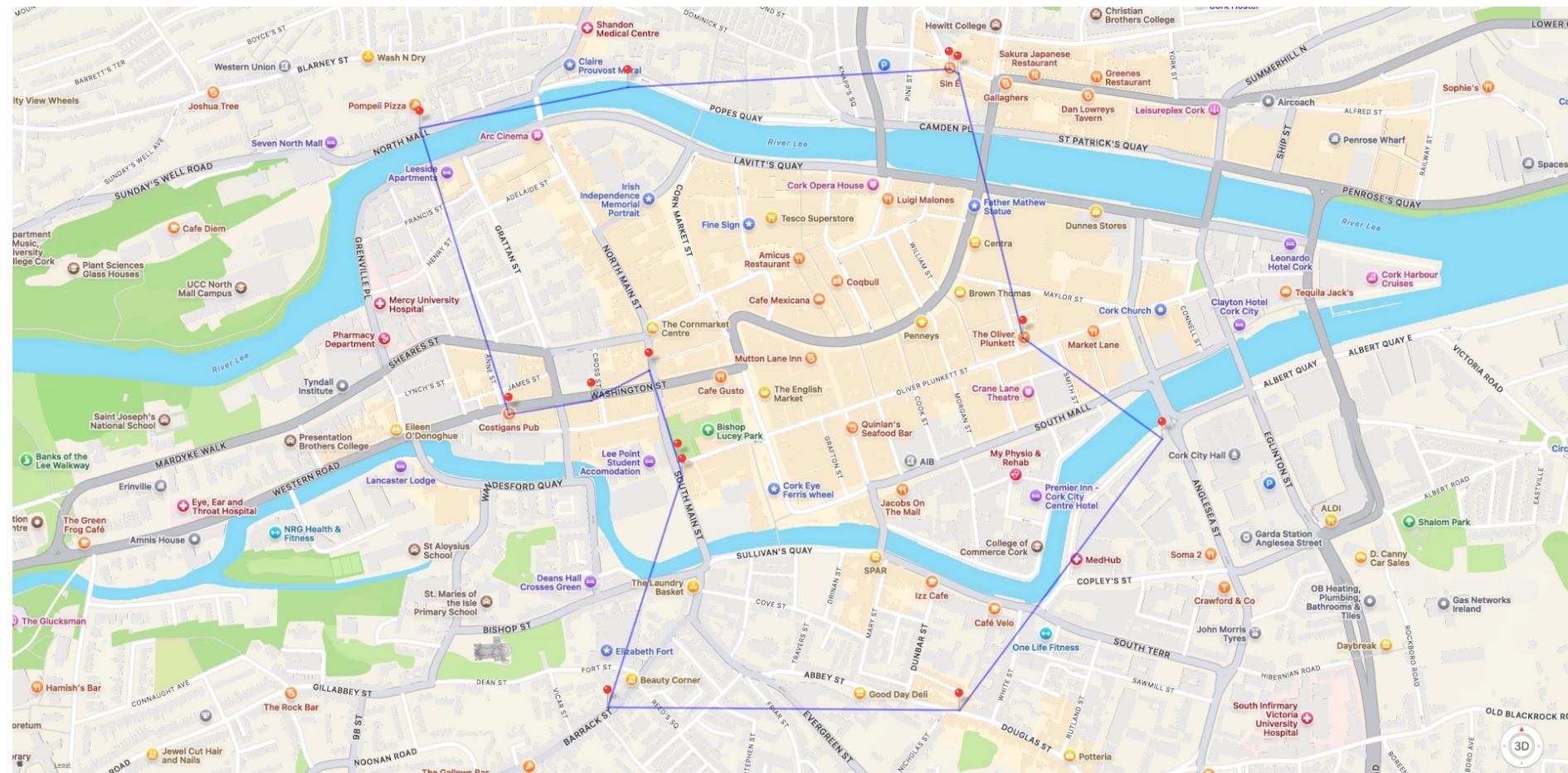
1. Define the problem ✓
2. Get distances between each pub ✓
3. Can not generate 20 million options ! ✗
4. Can not evaluate them all ✗
5. Only if he knows all 20 million solutions, he needs to sort first to choose the best ! ✓
6. Learning: this problem is beyond human capabilities! ✓



Best ever (Optimal) pub crawl : 3.520 km



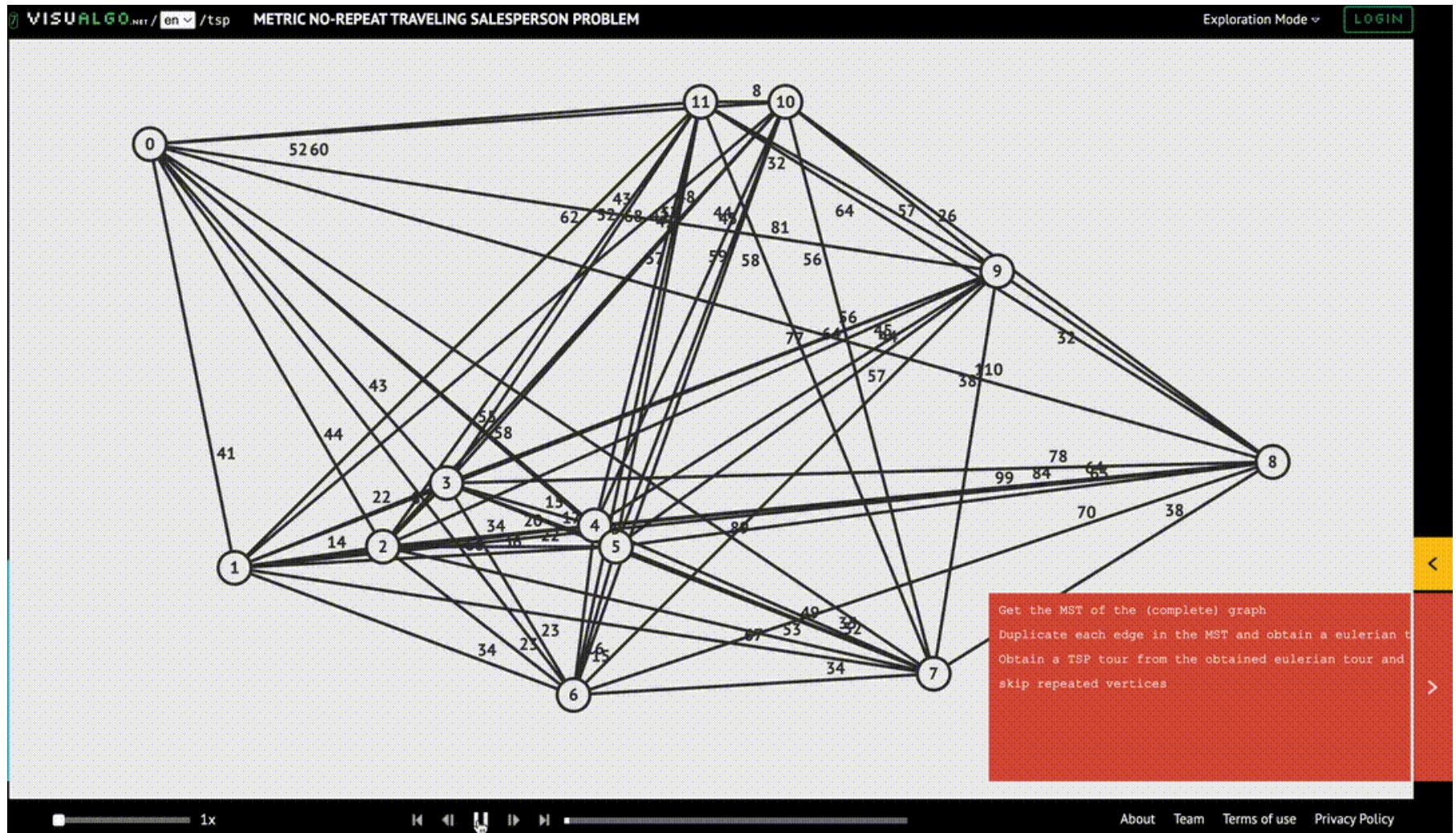
DIY (App Store)



How do we solve and know this is the best ever (optimal) tour ?



Any way faster (but not guarantee the best) ?



2 approximate algorithm (visualgo web app)

How do we speak our decision problem to the computer ?

- 1 Explain the problem to yourself first, plain English**
- 2 Formulate the problem as a decision problem**
- 3 Implement the decision problem in computer**

Plain English problem definition : conceptual model

Minimize

Total walking for Pub Crawl

(1)

Subject to

Travel each pub once

(2)

Back to Liberty at the end

(3)

Decision Problem formulation- mathematical programming model

Minimize

$$\sum_{i,j \in I} d_{ij} x_{ij} \quad (1)$$

subject to

$$\sum_{j \in I | j \neq i} x_{ij} = 1 \quad \forall i \in I \quad (2)$$

$$\sum_{i \in I | i \neq j} x_{ij} = 1 \quad \forall j \in I \quad (3)$$

$$u_i - u_j + |I| x_{ij} \leq |I| - 1 \quad \forall i, j \in I | (i > 1) \wedge (i \neq j) \quad (4)$$

$$x_{ij} \in \{0, 1\} \quad \forall i, j \in I \quad (5)$$

$$u_i \geq 0 \quad \forall i \in I \quad (6)$$

Decision Problem formulation-AI model

$$\text{Minimize} \quad \sum_{i=1}^{|I|-1} d_{x_i x_{i+1}} + d_{x_{|I|} x_1}$$

Subject to

$$\text{alldifferent}(x_1, x_2, \dots, x_{|I|})$$

$$x_i \in \{1, 2, \dots, |I|\} \quad \forall i \in I$$

Decision problem - implementation

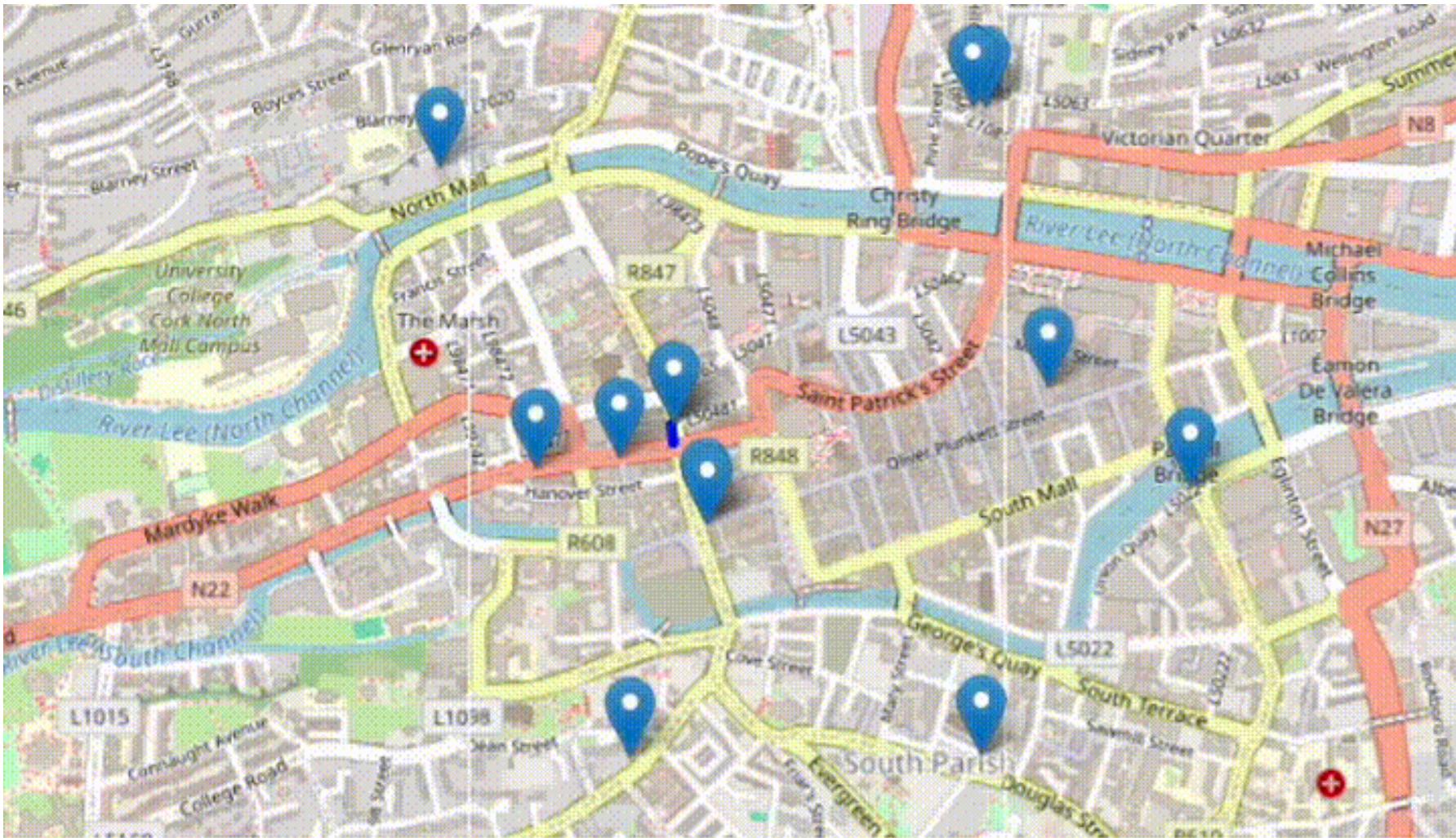


Google OR-Tools

openroute
service

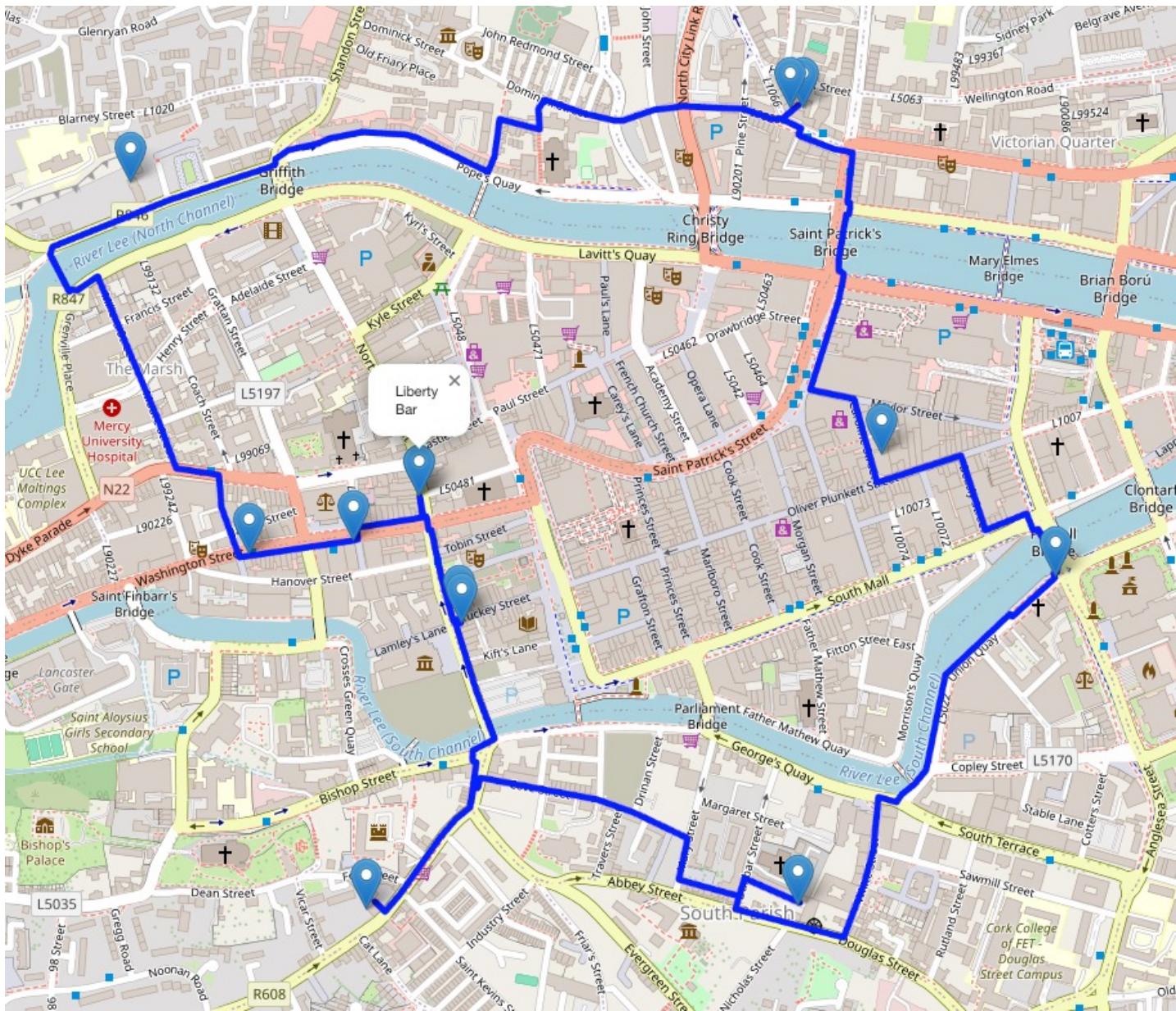
Access the implementation on [GitHub](#) and click “Open in Colab” to run it.

Optimized Pub Crawl with actual road distances



Optimized Route: Liberty Bar -> Dwyers -> Costigans ->
Franciscan Well -> Corner House -> Sin E' -> The Oliver Plunkett
-> Charlies -> Fionbarra -> Tom Barry's -> An Spailpin Fanach ->
The Oval -> Liberty Bar **Total Distance: 4.63 km**

Optimized Pub Crawl



Any business ?

***supply chain & logistics
manufacturing
airports/aviation
telecommunication
health services
financial services
media
education....***

