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# Combining Optimization and Machine Learning for Orienteering Problems : Reference Data conception

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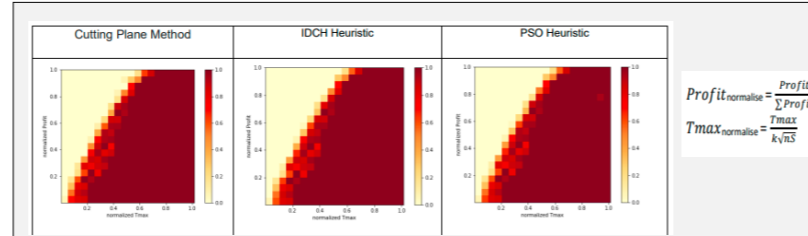
## Problem definition and objectives

### 1. Orienteering Problems :

- Two conflicting objectives: maximize the collected profit and minimize the routing costs.
- Constraints: Time budget Tmax, each node can be visited at most once.

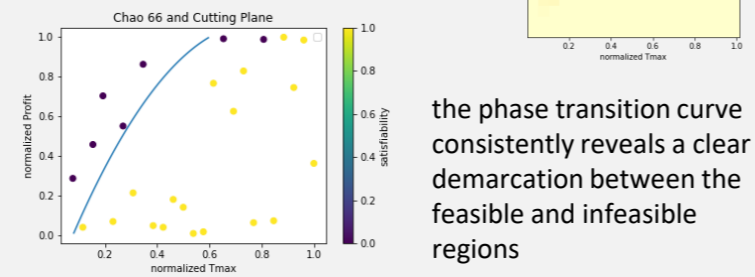
### 2. Objectives :

- Concepting a new dataset based on Phase Transition.
- Using a machine learning routine exploiting the phase transition results in order to enhance the efficiency of the Resolution Algorithm



- The plots show that the hard instances occur around the phase transition from solvability to unsolvability

Figure 1: Phase transition and average running time (CPU sec) for OP.

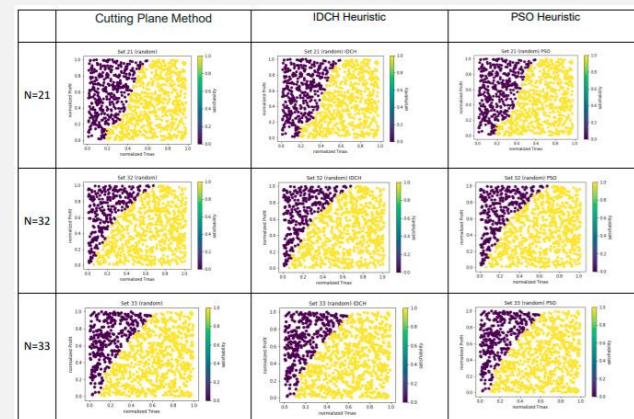


the phase transition curve consistently reveals a clear demarcation between the feasible and infeasible regions

Figure 2: The projection of Chao instances (n=66) onto the phase transition map.

## Phase Transition in NP-Complete Problems

- Phenomenon observed in randomly generated NP-complete problems.
- Relationship between the satisfiability of an instance and the computational effort of the solving algorithm.
- Comparison between three methods : Cutting Plane Method, IDCH, PSO



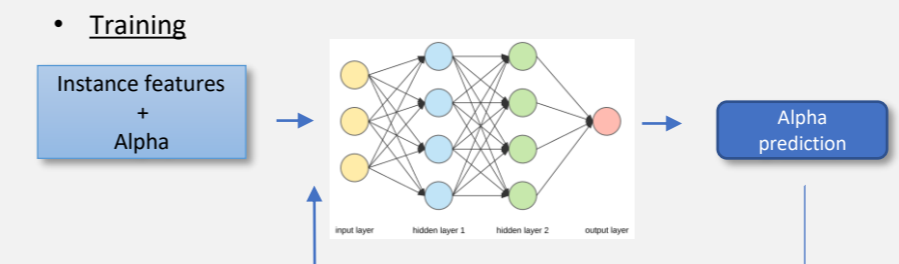
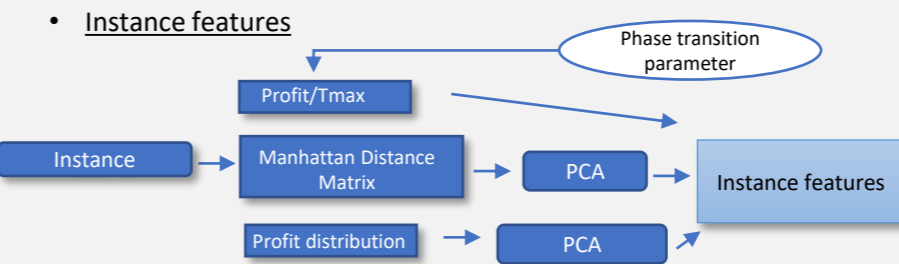
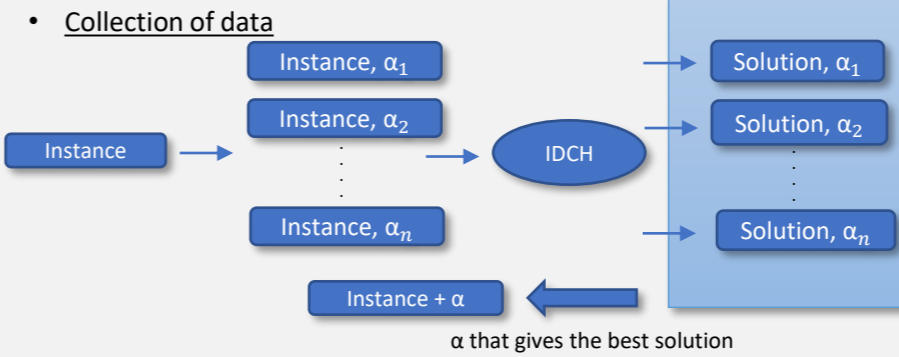
## Machine learning to enhance the insertion criterion in construction heuristic

### 1. Problem statement:

- The insertion cost for an unrouted customer z between customers i and j is calculated as follows :  

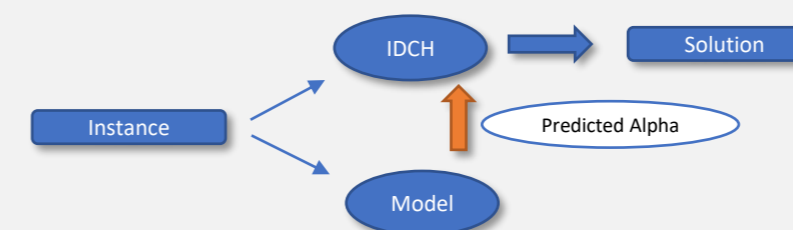
$$\frac{C_{i,z} + C_{z,j} - C_{i,j}}{(P_z)^\alpha}$$
- The manual adjustment of  $\alpha$  can be challenging and requires deep expertise => Using machine learning to learn how to adjust  $\alpha$ .

### 2. Proposed method :



- ✓ Several approaches to be tested: neural networks, Random Forest, nonlinear regressions.

### 3. Combination of model and the IDCH heuristic.



## Results

- ❑ The results show that the phase transition occurs when independently varying the parameter Profit/Tmax (tour cost).
- ❑ The Profit/Tmax parameter is an indicator of the difficulty of Orienteering Problem instances.

## Perspectives

- ❑ Using the Profit/Tmax parameter as a measure of difficulty to generate new dataset to train machine learning model.
- ❑ Using machine learning to enhance resolution algorithms.

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