AUGUST 2021

TEXAS
The University of Texas at Austin

2021 ASEM-CIE Hackthon

Automated Test in Production Planning in Test base Engineering

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Outline

- Background
- Task 1
  - Problem Definition
  - Technical Approach
- Task 2
  - Problem Definition
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  - Technical Approach
- Result
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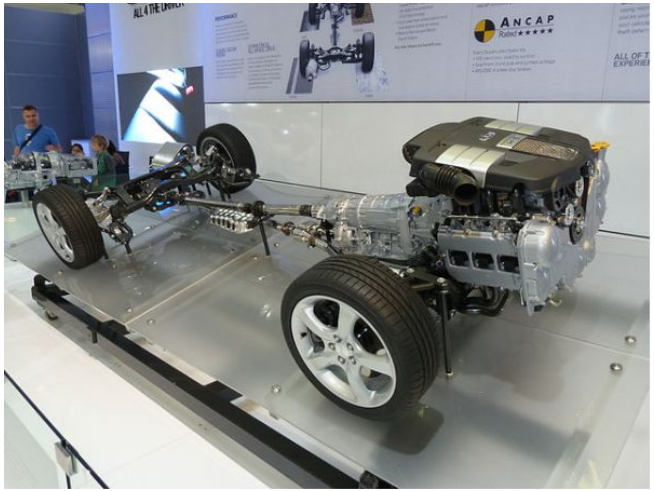
Background



Powertrain sensors
Powertrain current sensors
Powertrain exhaust sensors
Powertrain fluid concentration sensors
Powertrain knock sensors
Powertrain position sensors

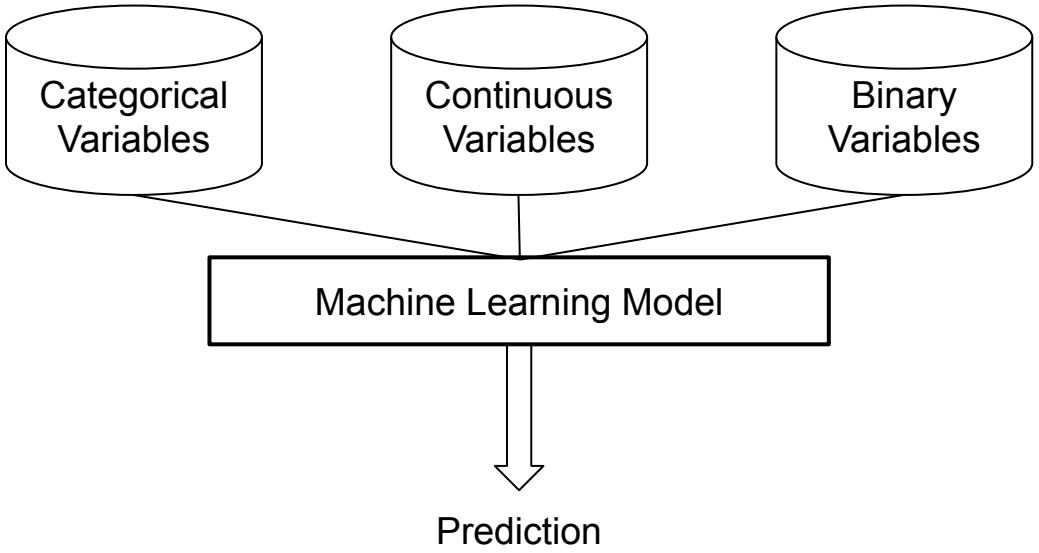
Transmission
Automatic transmission
Drive line components
Electric drive
Shifter system

Engine
Diesel engine
Engine fan
eTurbo/charger
Gasoline & diesel engine platform
Gasoline engine
Ignition
Pump

Power Steering
Electric power steering (EPS)

- Goal: Reduce total time required for flexible sequence of testing processes
- Limitation: Conflicting performance requirements, growing product complexity, cost and material limitation

Task 1 Problem Definition



Training data:

- Mixed input features
- Unknown relationship
- Small amount of data

Neural Network (NN) Model:

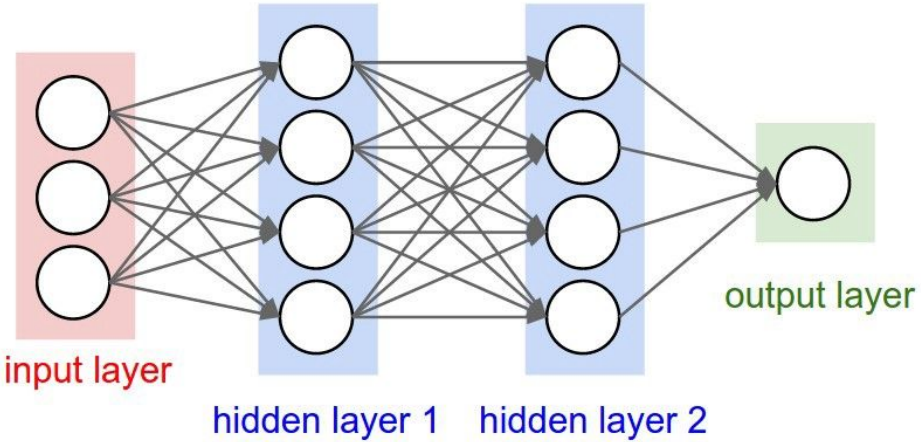
- Easy to handle mixed inputs
- Able to learn the relationship by itself
- Tunable and reliable

Test data:

- Predicted by trained NN

Task 1 Technical Approach

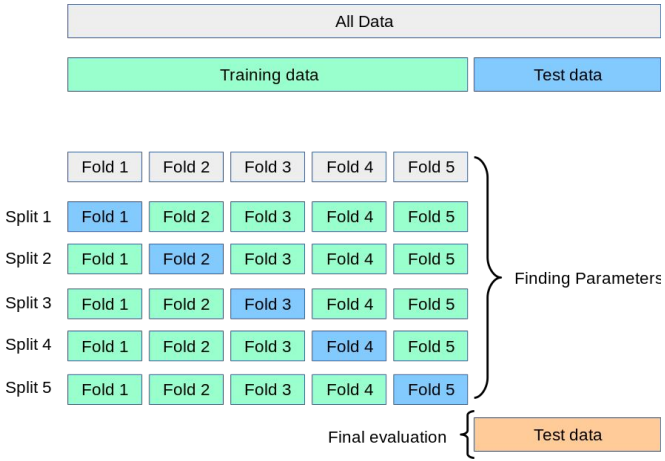
NN Model Training



35 mixed inputs

hidden layer: 1-3

1 output



K-fold cross validation

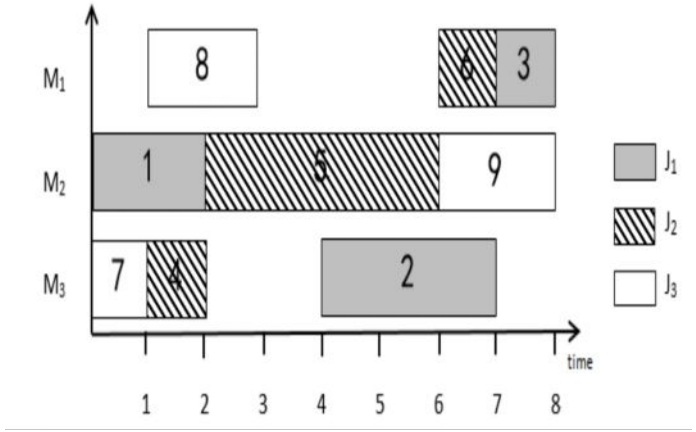
Min validation error:
2 hidden layers

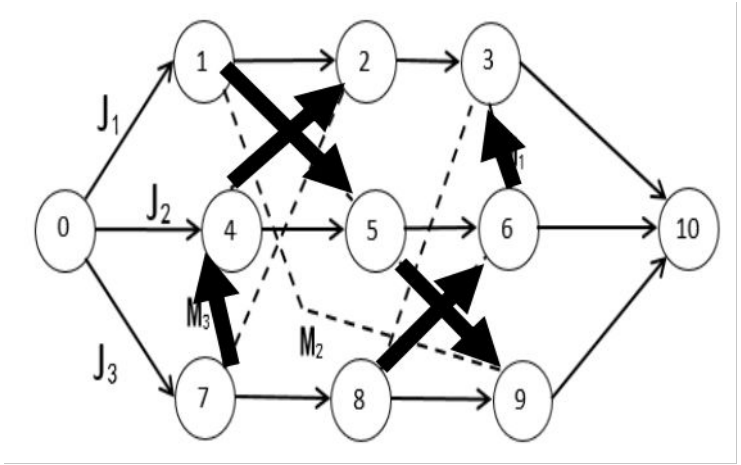
Task 2 Problem Definition

- *n* jobs are processed on *m* machines
- Each job consists of a sequence of operations, which must be performed in a given order
- Each operation must be processed on a specific machine
- A machine can only work on one operation at a time
- An operation, once started, must run to completion
- No operation for a job can be started until the previous operation for that job is completed.
- Minimize makespan, i.e., the maximum completion time

Task 2 Problem Definition

Order	1st	2nd	3rd
Job 1	1 (Machine 2, 2s)	2 (Machine 3, 3s)	3 (Machine 1, 1s)
Job 2	4 (Machine 3, 1s)	5 (Machine 2, 4s)	6 (Machine 1, 2s)
Job 3	7 (Machine 3, 1s)	8 (Machine 1, 2s)	9 (Machine 2, 2s)





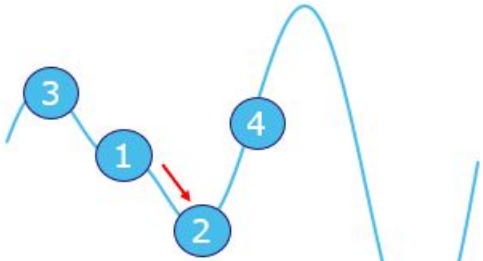
Task 2 Literature Review

- Johnson's Rule (Johnson, 1953)
- Priority Rules (Gere Jr, 1966)
- Shifting Bottleneck (Adams, Balas and Zawack, 1988)
- Lagrangian Relaxation (Hoitomt, Luh and Pattipati, 1993)
- Branch and Bounds (Brucker, Jurisch and Sievers, 1994)
- Local Search Based Metaheuristics
  - Genetic Algorithm (Davis, 1985)
  - Tabu Search (Dell'Amico and Trubian, 1993)
  - Simulated Annealing (Van Laarhoven, 1992)
  - Particle Swarm Optimization (Sha and Hsu, 2006)

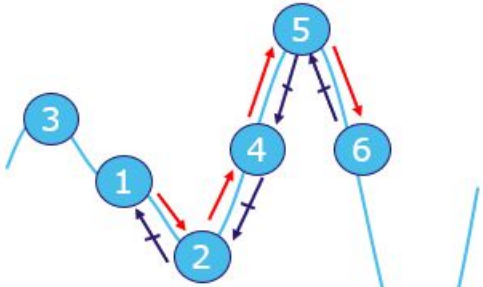
Task 2 Technical Approach

Local Search Based Metaheuristics:

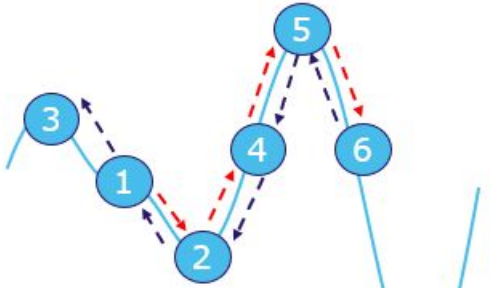
- Local Search: Only accepts better solutions
- Tabu Search: Prohibits already visited solutions using a tabu list
- Simulated Annealing: Has a decreasing probability to accept worse solutions



V(1)={2,3}
V(2)={1,4}



V(1)={2,3} T={1}
V(2)={1,4} T={2,1}
V(4)={2,5} T={4,2,1}
V(5)={4,6} T={5,4,2}

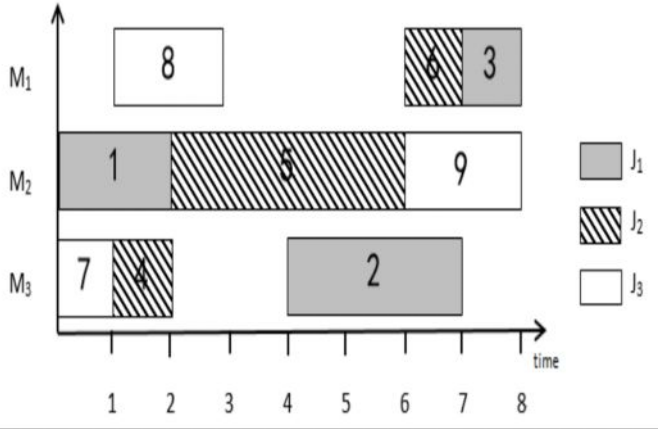


V(1)={2,3}
V(2)={1,4}
V(4)={2,5}
V(5)={4,6}

Task 2 Technique Approach

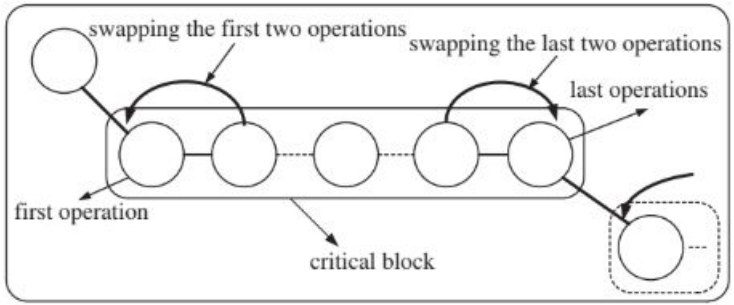
Neighborhood Structure:

- Critical path
  - The longest path in the graph
  - Critical blocks: consecutive critical operations on the same machine
- Only moves in critical path can reduce makespan

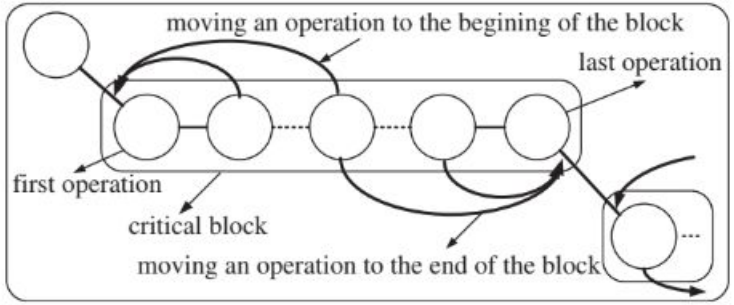


Task 2 Technique Approach

- N5 (Nowicki and Smutnicki, 1996)
  - Swaps the first/last two operations in a critical block

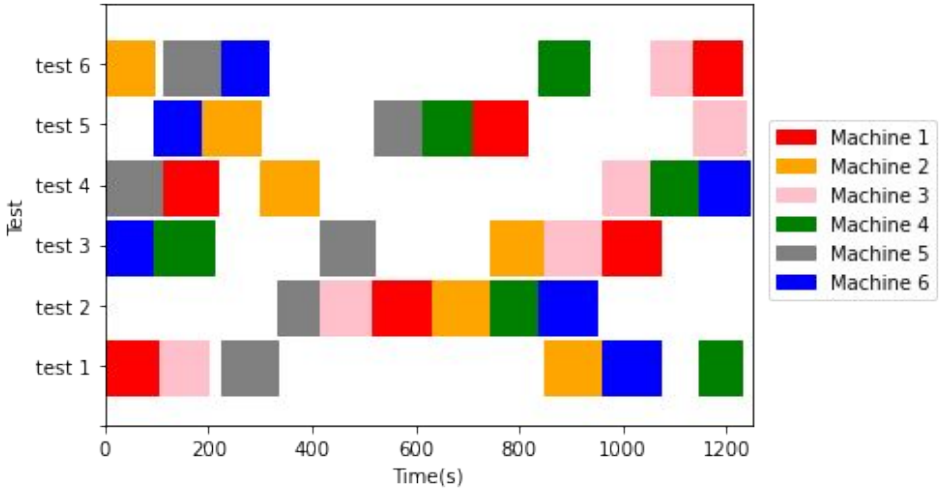


- N6 (Balas and Vazacopoulos, 1998)
  - Inserts the inner operations in a critical block to the first/last position

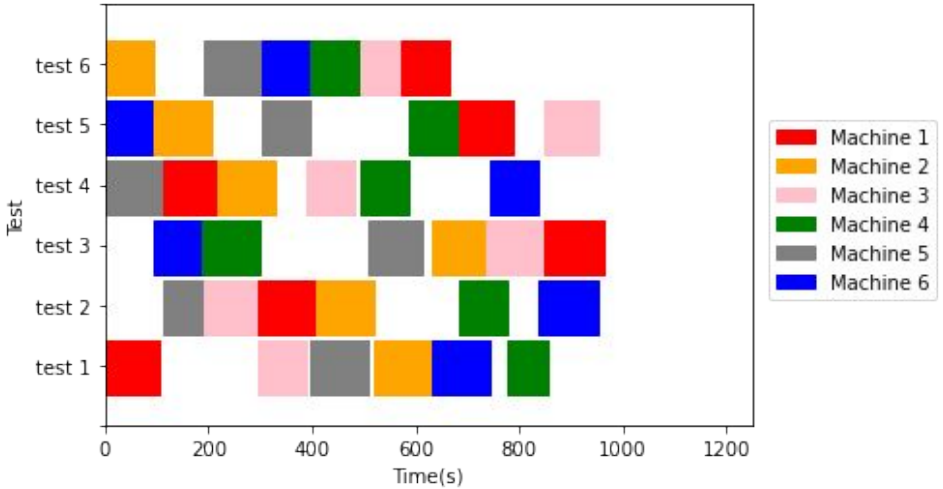


Result

- Naive Scheduling: 3658s
- Bidirectional Ordering Heuristic: 1242s
- Local Search Based Metaheuristics: 944s



Bidirectional Ordering Heuristic



Local Search Based Metaheuristics

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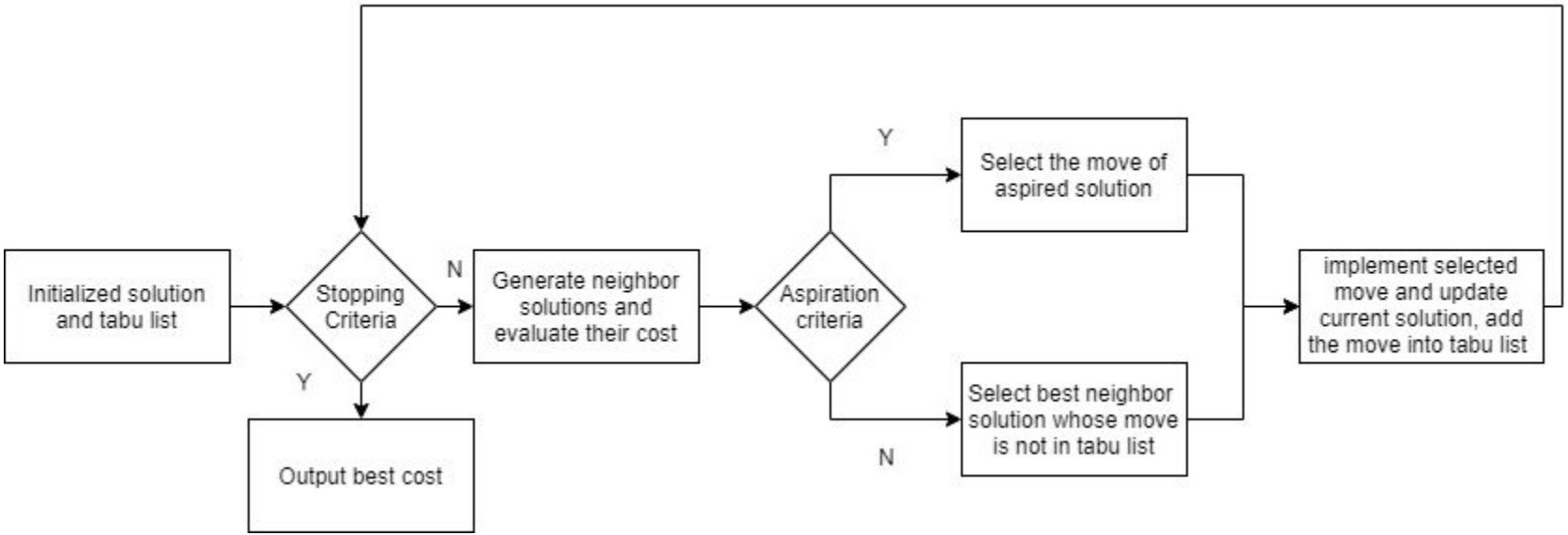
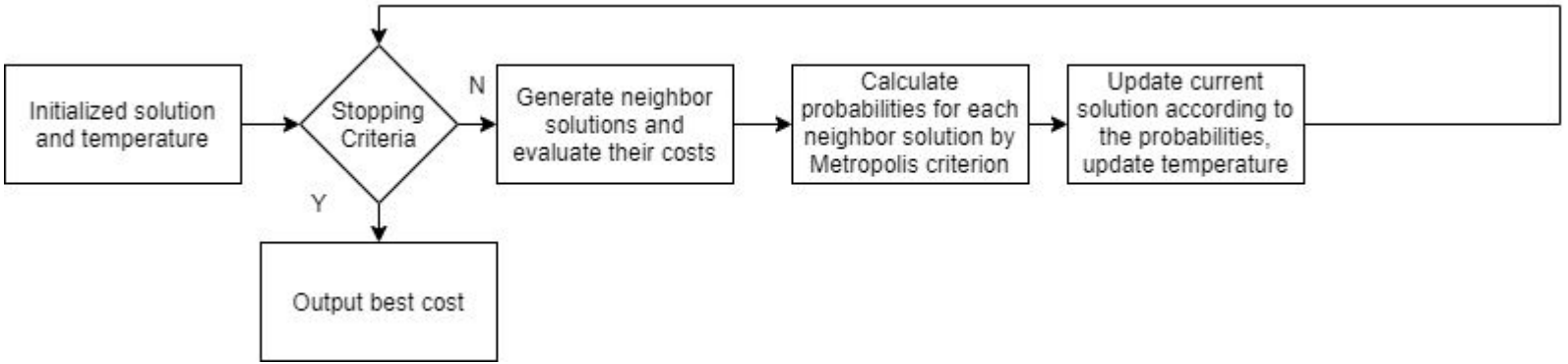
Thank you !

Appendix



Tabu Search Algorithm Flowchart

Appendix



Simulated Annealing Algorithm Flowchart