

Netherlands Defence Academy

# Hybrid Metaheuristic Planning & Military Decision-Making

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# Outline

Introduction

AI planning theory:

- Classical planning
- Hybrid metaheuristic scheduling

Military operational decision-making process:

- NATO process
- Naturalistic process

Comparing DMP to HMS

Conclusions & recommendations

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# AI Planning theory

Seen everywhere in everyday life:

- Resource allocation
- Timetabling
- Sensor management
- Routing or Navigation

# Classic Planning (2)

Features of Classical planning problems:

- Finite set of states in the domain
- Complete & Certain knowledge of domain
- The domain is completely controllable
- Well defined goals & actions

# Hybrid Metaheuristic Scheduling

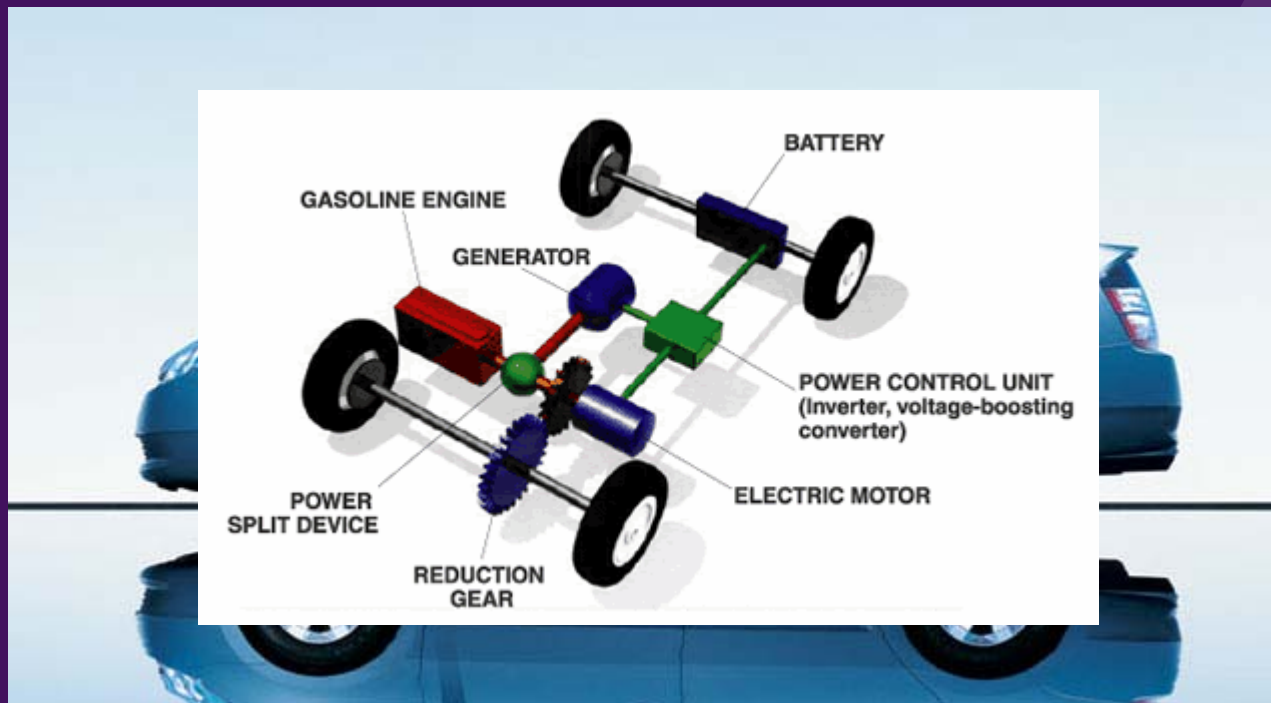
Features of realistic planning problems:

- Infinite set of states
- Incomplete and uncertain knowledge
- The domain is uncontrollable.
- Response to own actions can be unpredictable.
- Ill-defined and competing goals



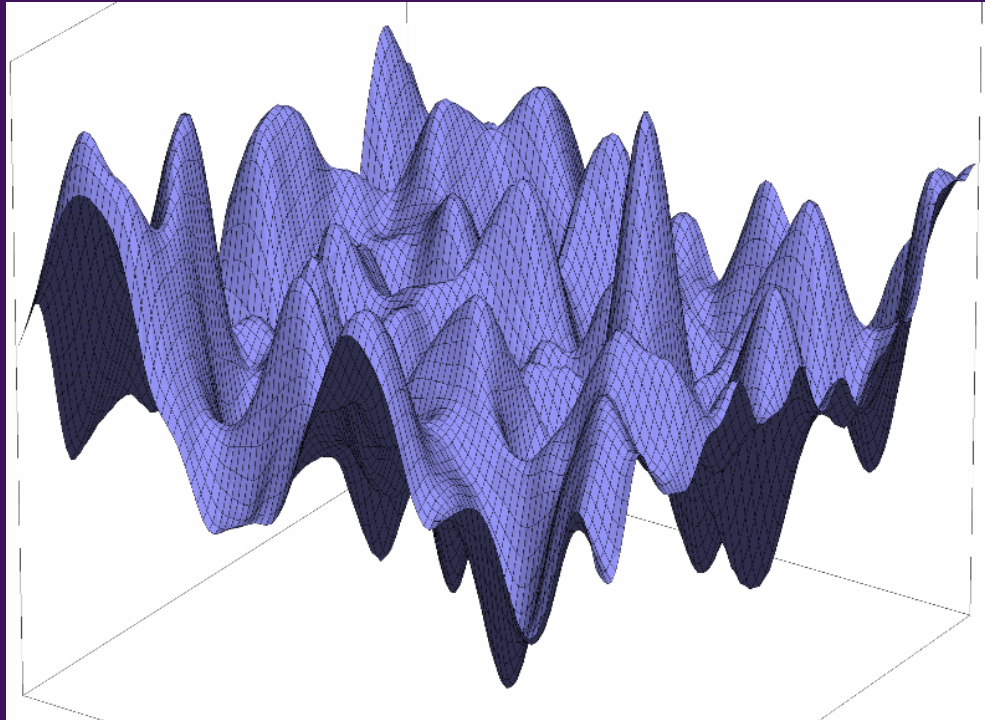
# Hybrid Metaheuristic Scheduling (2)

# What is hybridization?



# Hybrid Metaheuristic Scheduling (3)

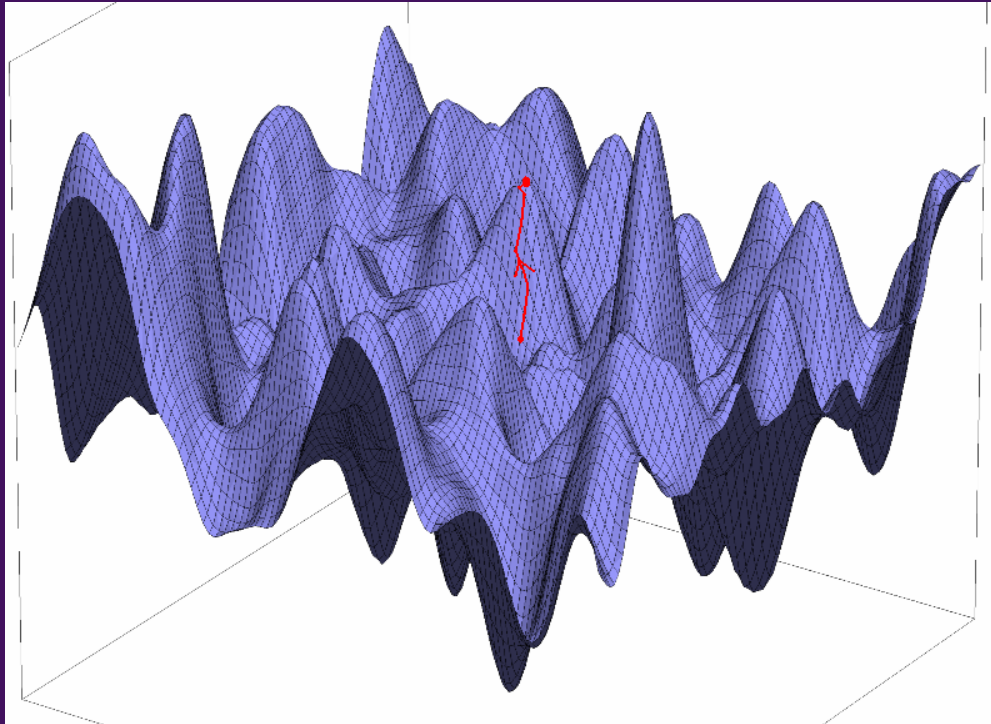
How does hybridization work for *Metaheuristics*?



Consider the ‘Solution Space’ as a Fitness Landscape

# Hybrid Metaheuristic Scheduling (3)

How does hybridization work for *Metaheuristics*?

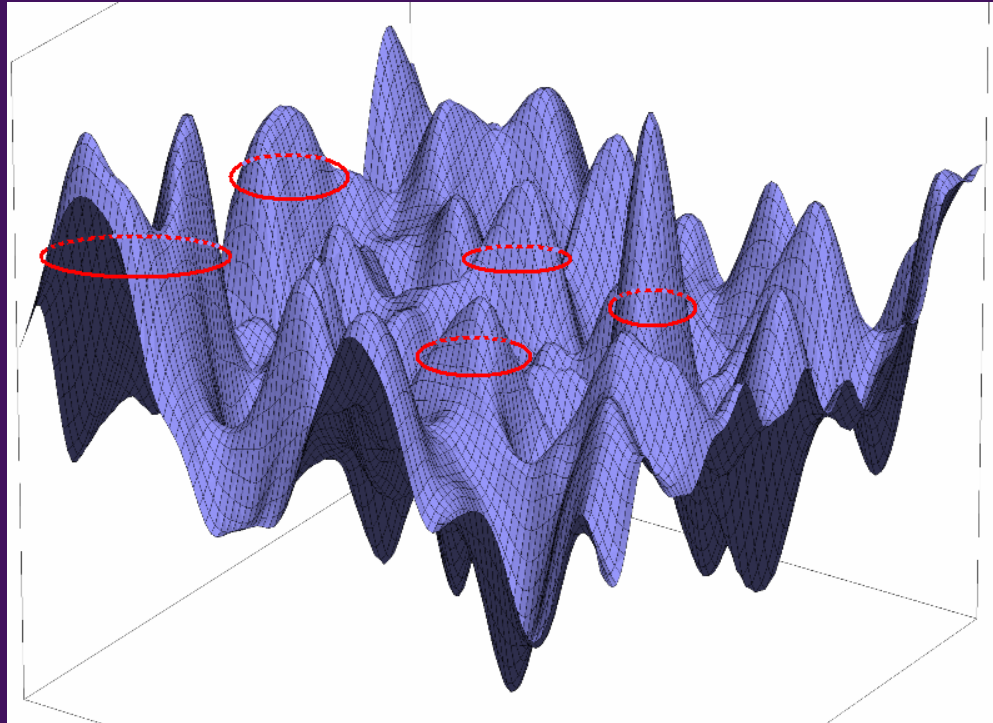


A single, simple heuristic finds the top

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# Hybrid Metaheuristic Scheduling (3)

How does hybridization work for *Metaheuristics*?

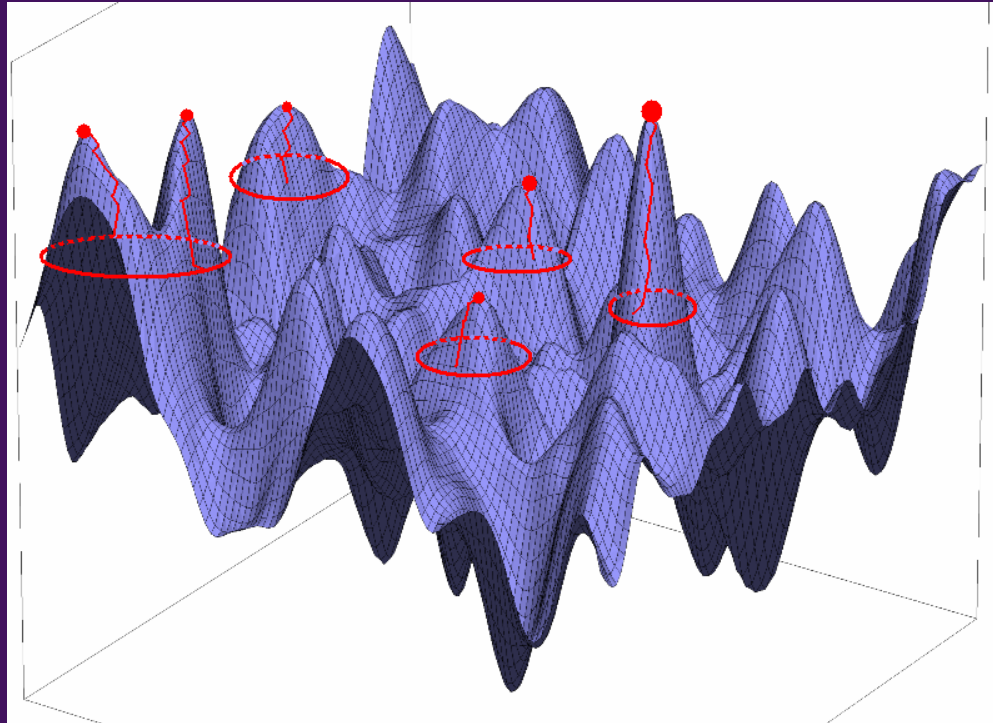


A Metaheuristic finds promising regions

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# Hybrid Metaheuristic Scheduling (3)

How does hybridization work for *Metaheuristics*?



A *hybrid* metaheuristic combines best of both



# Hybrid Metaheuristic Scheduling (4)

Hybrid Algorithms (Burke 2003):

- Faster than single algorithms
- More robust
- More broadly applicable
- Better solutions

Questions for Hybrid algorithms:

- What algorithms are most suitable for the current stage of the plan generation process?
- How can they be 'glued' together?



# Military decision making process

## NATO Standard DMP:

1. Analyze the assignment
2. List up all possible solutions
3. Make a correct and complete list of evaluation criteria
4. Evaluate solutions according to the criteria
5. Choose the best one



# Military decision making process (2)

## Problems with NATO Standard DMP:

- Enormous amount of possible actions
- Time consuming
- Assumes correct & complete knowledge
- Evaluation criteria often incomparable

Therefore: hardly ever followed (Holewijn, 2004)



# Military decision making process (3)

## Recognition Primed Decision Making

“I don’t make decisions. I don’t remember when I’ve ever made a decision.”

-Firefighter in interview (Klein, 1998).

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# Military decision making process (4)

## Recognition Primed Decision Making

- Power of intuition
- Power of mental simulation
- Focus on *situation assessment*, not on *decision events*.
- Primed to *act*, not to *wait for complete analyses*



# Comparing HMS to DMP

Features	Hybrid Metaheuristics	NATO DMP	RPDM
<b>Goals</b>	Well-defined, but shifting	Well-defined, constant, and coherent	Ill-defined, shifting
<b>Information</b>	Uncertain and incomplete	Uncertain & incomplete, but intelligence process to make it certain & complete	Uncertain, ambiguous, incomplete
<b>Conditions</b>	Dynamic, multi competing criteria	Constant, small number of coherent criteria	Dynamic, multi competing criteria
<b>Outside world</b>	Uncontrollable	Completely controllable or predictable.	Uncontrollable
<b>Feedback</b>	Action-feedback loops (real-time reactions to changed conditions)	To next operation, not this one	Action-feedback loops (real-time reactions to changed conditions)
<b>Time constraints</b>	Severe time stress	Ample time	Time Stress
<b>Experience of Decision Makers</b>	Experience is 'hard wired' in algorithms	Experience nice to have.	Experienced
<b>DM: Simulation</b>	No forecasting of future	No forecasting of future	Mental simulation to forecast plan results

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# Comparing HMS to DMP (2)

Lessons from DMP to Hybrids:

- More **self awareness** – assessing the qualities of constituting algorithms
- More **Situation Awareness** – assessing the situation better, applying yourself accordingly
- **Stop starting from scratch**, do more ‘Recognition Primed’ planning – use a template when a previous problem is recognized.
- **Predict the future** – to better evaluate plans

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# Comparing HMS to DMP (3)

Lessons from HMS to Military Decision Making:

- **Multidisciplinary cooperation** – perform better in unfamiliar situations
- **Distributed planning** – perform simultaneous planning independently, afterwards evaluation & merging
- **Intertwined planning** – Different hierarchy levels and different army disciplines work on the same planning at the same time. This speeds up the process and enhances situation awareness.

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# Summary

- Indications for applying Hybrid Metaheuristics are similar to indications that led to Recognition Primed Decision Making.
- On the solution side: Hybrid Metaheuristics are lacking Situation Awareness, Recognition skills, Learning.
- On the solution side: Military Decision Making lacks Intertwined, simultaneous planning.
- Research projects at NLDA and DECIS are aimed at answering these questions.



# References

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# Questions

