

A Formalism for Optimal Search with Dynamic Heuristics

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ICAPS 2025

2025-11-11

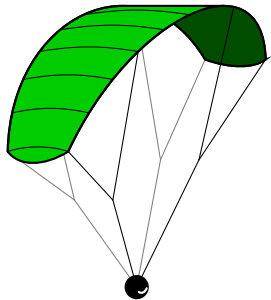
Setting

- classical, optimal planning
- heuristic search
- *dynamic heuristics*

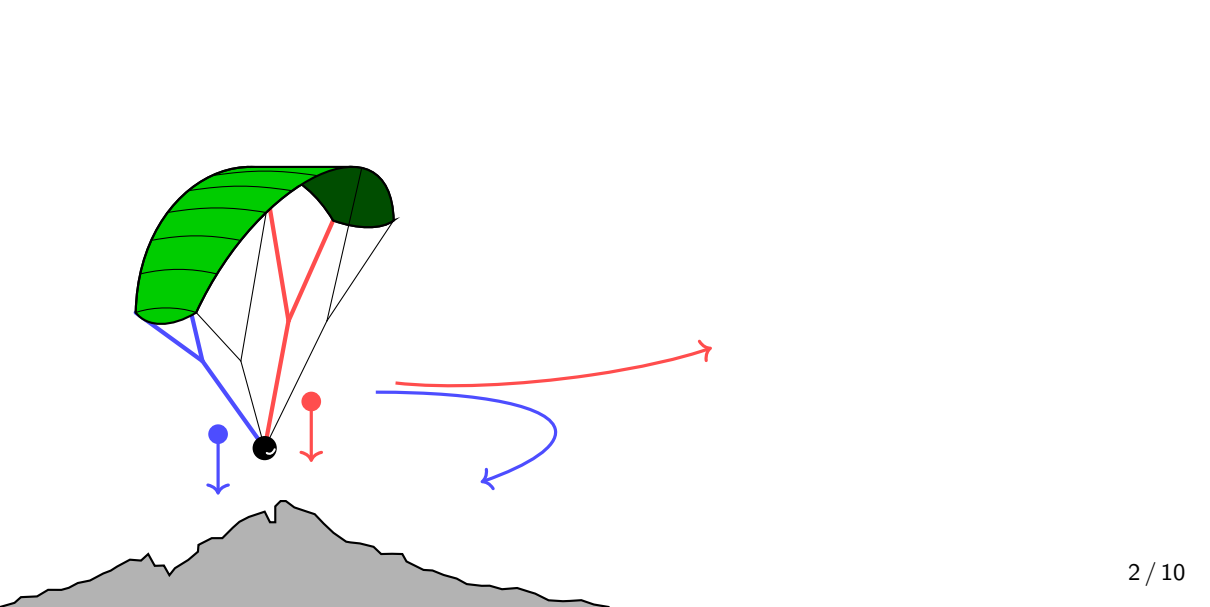
Brisen



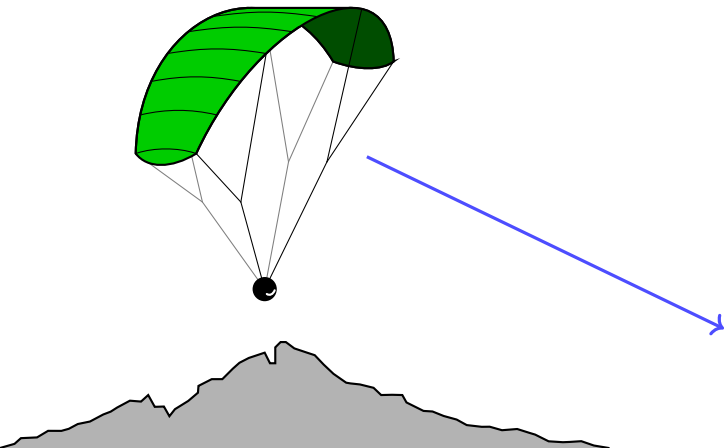
Paragliding



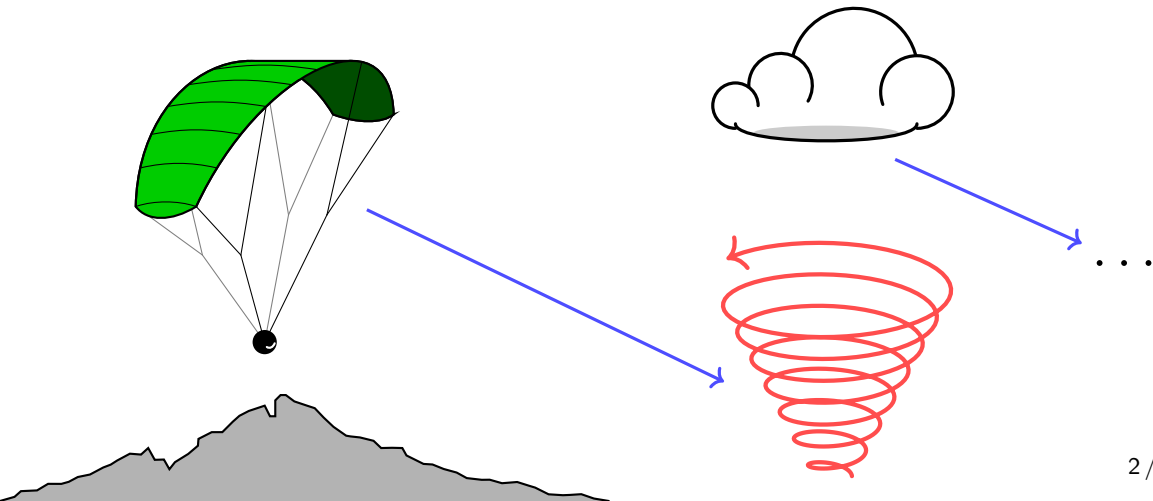
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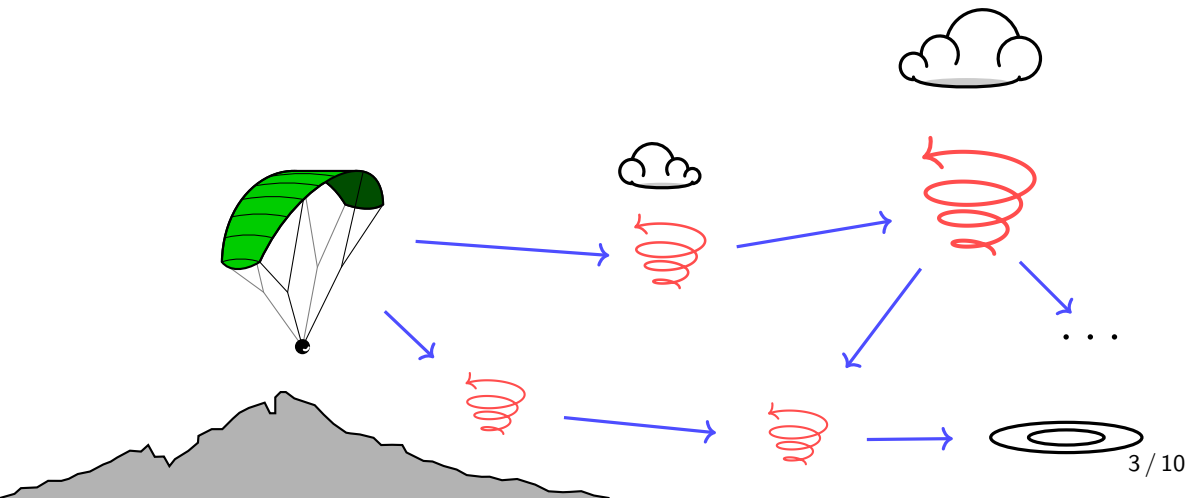
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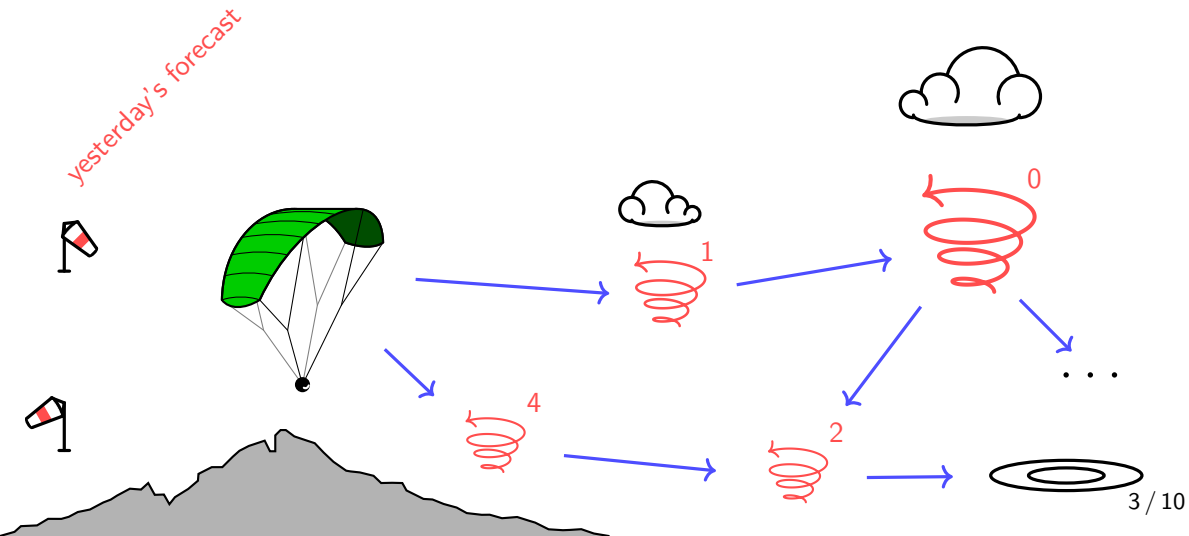
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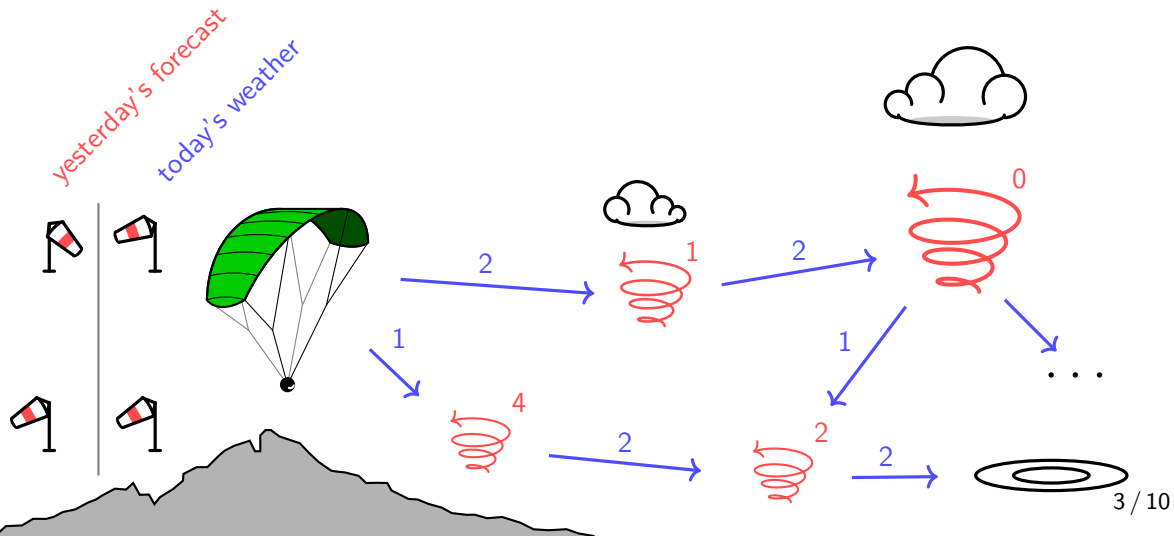
Flight Plan



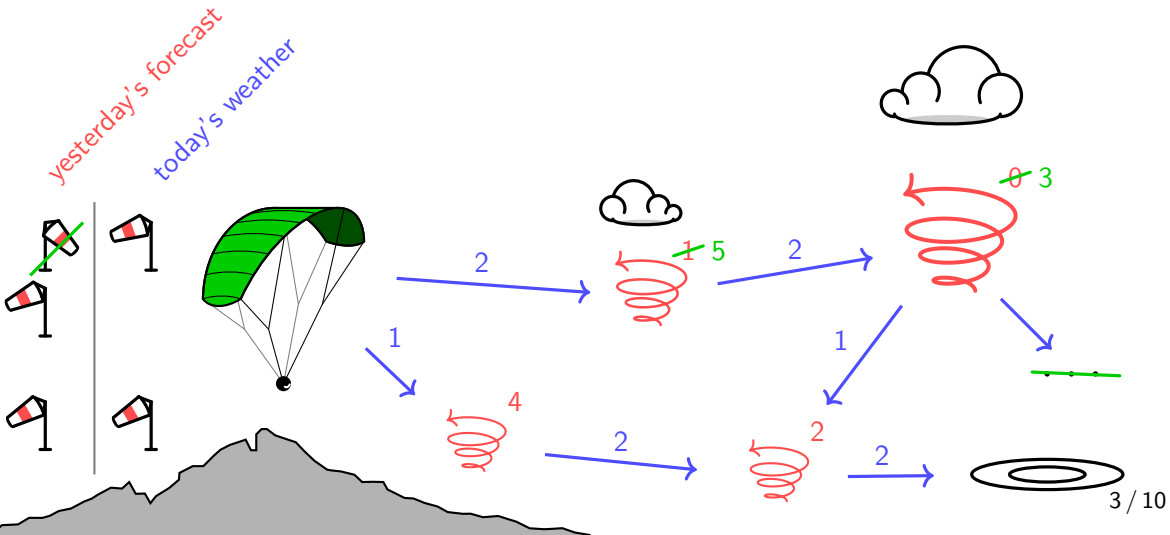
Flight Plan



Flight Plan



Flight Plan



Existing Approaches

- online Cartesian abstraction refinement (Eifler and Fickert, 2018)
- interleaving search and abstraction improvement (Franco and Torralba, 2019)
- landmark progression (e.g., Büchner et al., 2023)

Appeal to classic result:

$A^* + \text{admissible heuristic} = \text{optimal solutions}$

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Appeal to classic result:

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Not so trivial!

- static property
- interaction between search and heuristic

Formalism — Heuristics

Changes to **heuristics**

- make heuristic **information-dependent**

$$h(\text{spring}) \Rightarrow h(\text{spring}, \text{lamp})$$

- **extend** heuristic **properties** to dynamic case

$$\dots \text{for each spring} \Rightarrow \dots \text{for each spring and lamp}$$

- define **monotonicity** property

h -values may not decrease

Changes to **search**

- explicitly model **information updates**
- add optional **check**

initialize

while open is not empty **do**

refine

re-evaluation check

goal check

for all successors **do**

update

insert into open

DYN-A*

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DYN-A*

Proposed Solution

- static property
⇒ define **dynamic properties**
- interaction between search and heuristic
⇒ model via **information**
 used by heuristic
 updated by search

Results

Optimal Solution

DYN-A* with a **DYN-admissible** dynamic heuristic returns **optimal solutions**.

No Reopening

DYN-A* with **re-evaluation** enabled and using a **DYN-monotonic, DYN-consistent** dynamic heuristic does **not reopen** states.

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Optimal Solution

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No Reopening

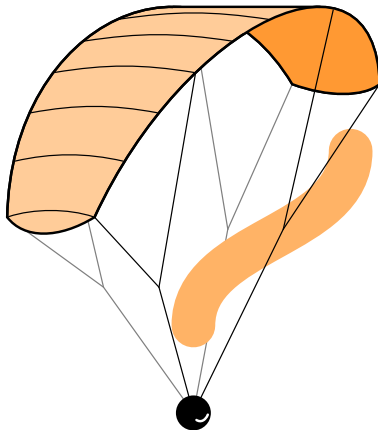
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Applying Results

- model approach as a **DYN-A*** search with a **dynamic heuristic**
- show that relevant properties hold **initially**
- show that **updates do not violate** properties

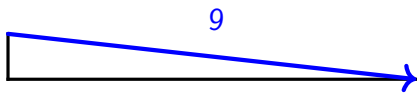
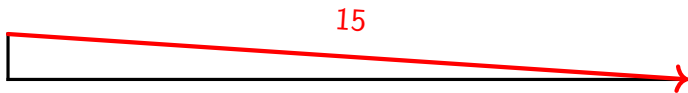
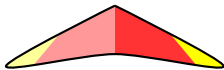
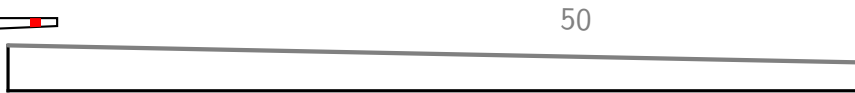
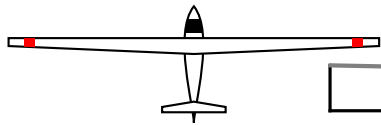
- extend to search with **deferred evaluation**
- extend to **bounded suboptimal** search
- treat *g-values* in a unified way
- **optimal efficiency**

Questions

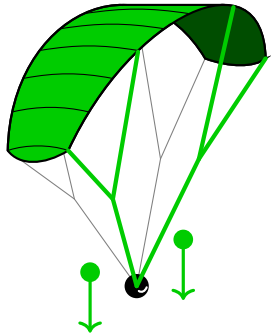


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Glide Ratios



Accelerate



~~30~~ 35 km/h

