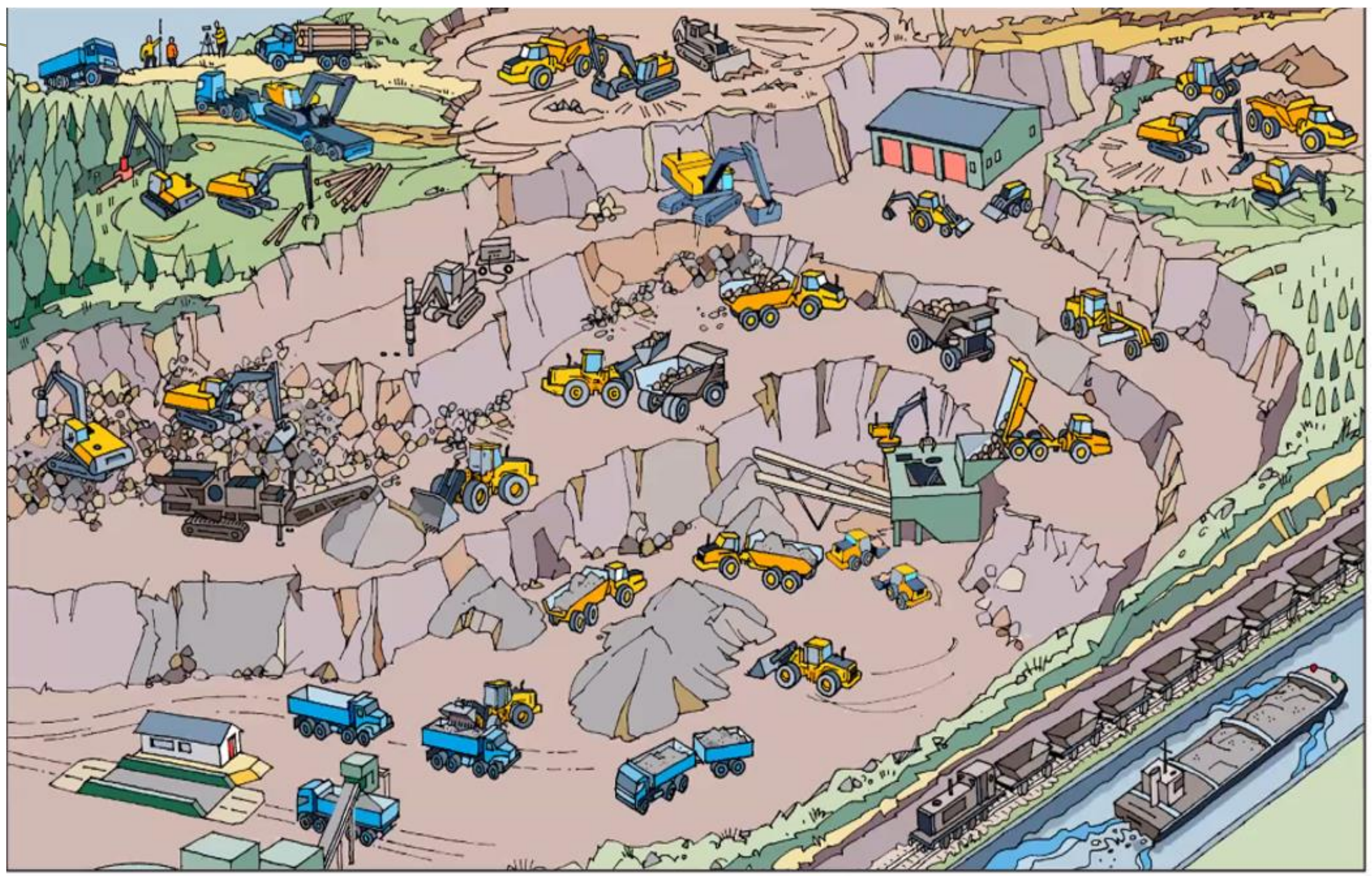
Construction Site Automation: Open Challenges for Planning and Robotics

Paolo Forte, Anna Mannucci, Henrik Andreasson, Federico Pecora
Center for Applied Autonomous Sensor Systems (AASS), Örebro University

Örebro University

Multi-Robot Planning and Control Lab



Industrial/Societal interest

- Automate material flow planning and coordination to improve productivity and increase safety
- Construction operations, such as loading, unloading and moving material, are repetitive, and therefore suitable for automation [1,2].
- Robots appropriate where human presence is undesirable, unsafe, or impossible.

Background

- Very little automation in construction [3,4]
- Challenges: harsh environment, heterogeneous robots, large fleets, collaborative tasks, online replanning .
- Tight coupling between task planning, motion planning, coordination and control

Research Questions

1) "How to represent material, material properties and material behaviour?"

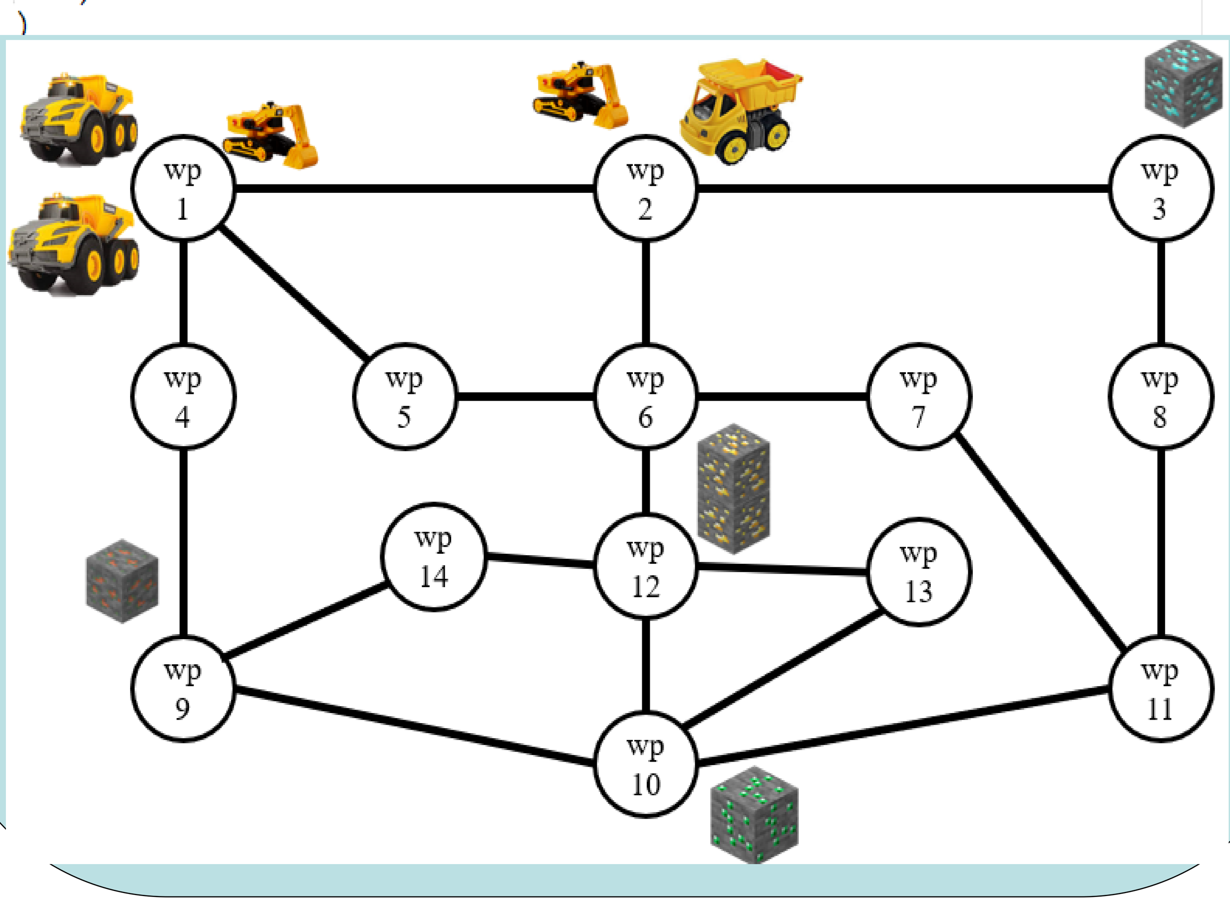
2)"How to automate the earthmoving process in construction sites? "

3) "How to solve the task assignment, sequencing, motion planning and control problems jointly?"

Discrete Formulation [PlanRob 2021]

Combines elements of Sokoban and Blocks-World domain

```
(:action load_material
    :parameters (?rb - robot ?mat - material ?loc - location)
    :precondition (and
        (at ?rb ?loc)
        (bulldozer ?rb)
        (idle ?rb)
        (isopen ?mat)
        (material_start_position ?mat ?loc)
    )
    :effect (and
        (in ?mat ?rb)
        (not (idle ?rb))
        (decrease (material_amount_at_location  ?mat ?loc) (machine_capacity ?rb))
        (increase (cost_eartmoving_processes) (BulldozerActionCost ?rb))
    )
)
```



Gazebo Simulation

Two robots moving pallets

https://youtu.be/wQl8htZ5hbw

Continuous Formulation [5]

$$\min_{\boldsymbol{z}} \quad \alpha_0\, \mathcal{B}(\mathcal{P}^{\mathrm{TA}}, \boldsymbol{z}) + (1-\alpha_0)\, \mathcal{F}(\mathcal{P}^{\mathrm{all}}, \boldsymbol{z})$$

$$\text{s.t.} \qquad z_{ijs} \in \{0,1\},$$

$$\sum_{r_i \in \mathcal{I}} \sum_{s=1}^{p_{ij}} z_{ijs} = 1 \quad \forall \pi_j \in \Pi,$$

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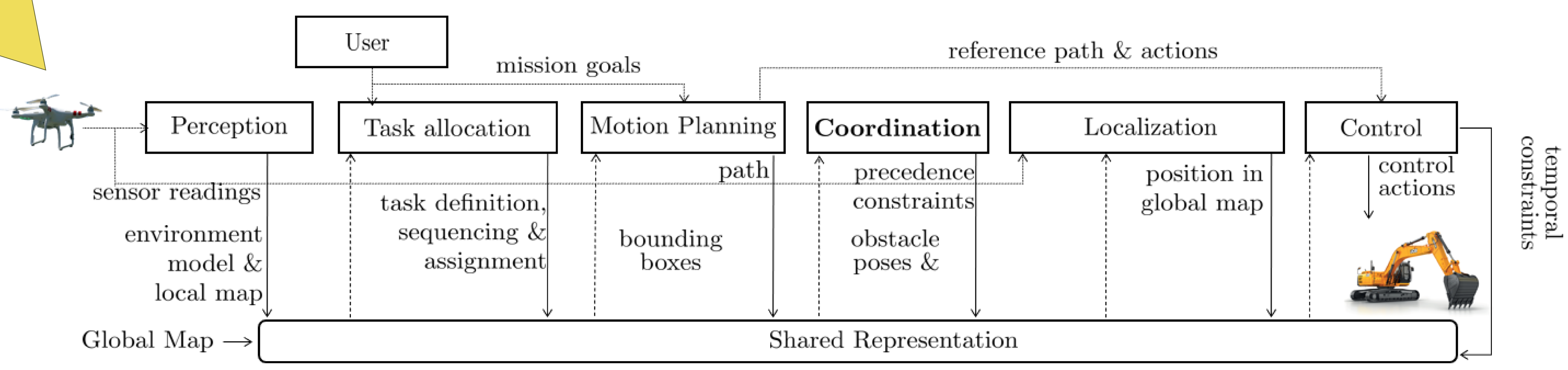
$\mathcal{B}(\mathcal{P}^{\mathrm{TA}}, \boldsymbol{z})$: Interference-free cost function

$\mathcal{F}(\mathcal{P}^{\mathrm{all}}, \boldsymbol{z})$: Interference cost function



References

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Contact: Paolo Forte; paolo.forte@oru.se