

Path planning for unloading task of autonomous head-feeding combine

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Autonomous agricultural machinery

- Reducing human labor
- High efficiency
- Precision agriculture

and so forth...

Autonomous head-feeding combine for rice plant harvesting



- RTK- GPS
as position sensor
- GPS compass
as attitude sensor

VY50 (Mitsubishi Agricultural machinery Co., Ltd.)

Unloading task of combine in Japan



Truck is waiting combine on the farm road and the combine comes next to the truck to unload harvested grain when the grain tank is filled.

Objective

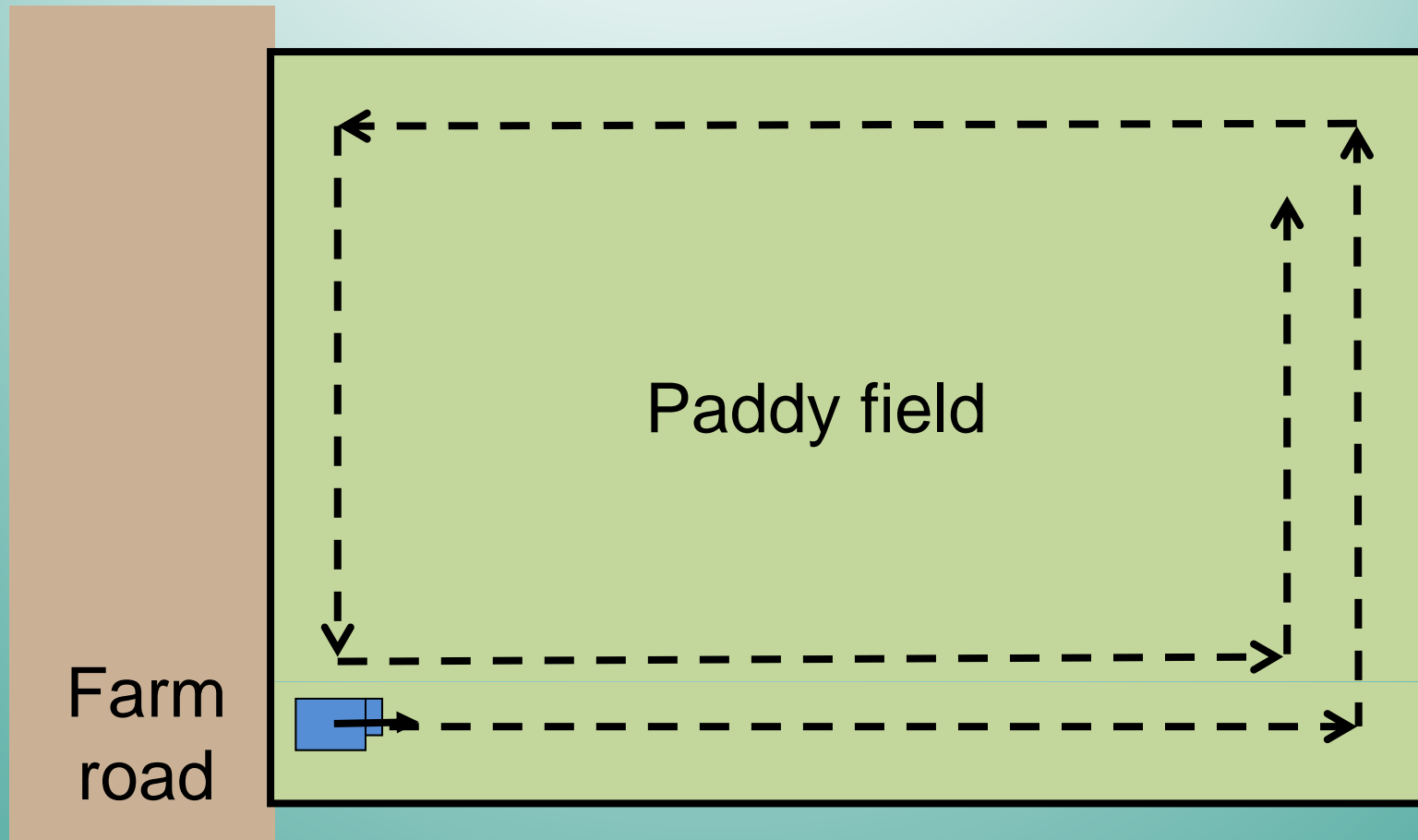
To develop path planning method for unloading task of autonomous combine.

Path planner for planning

- path to the unloading point.
- path from the unloading point to the restarting point of harvesting

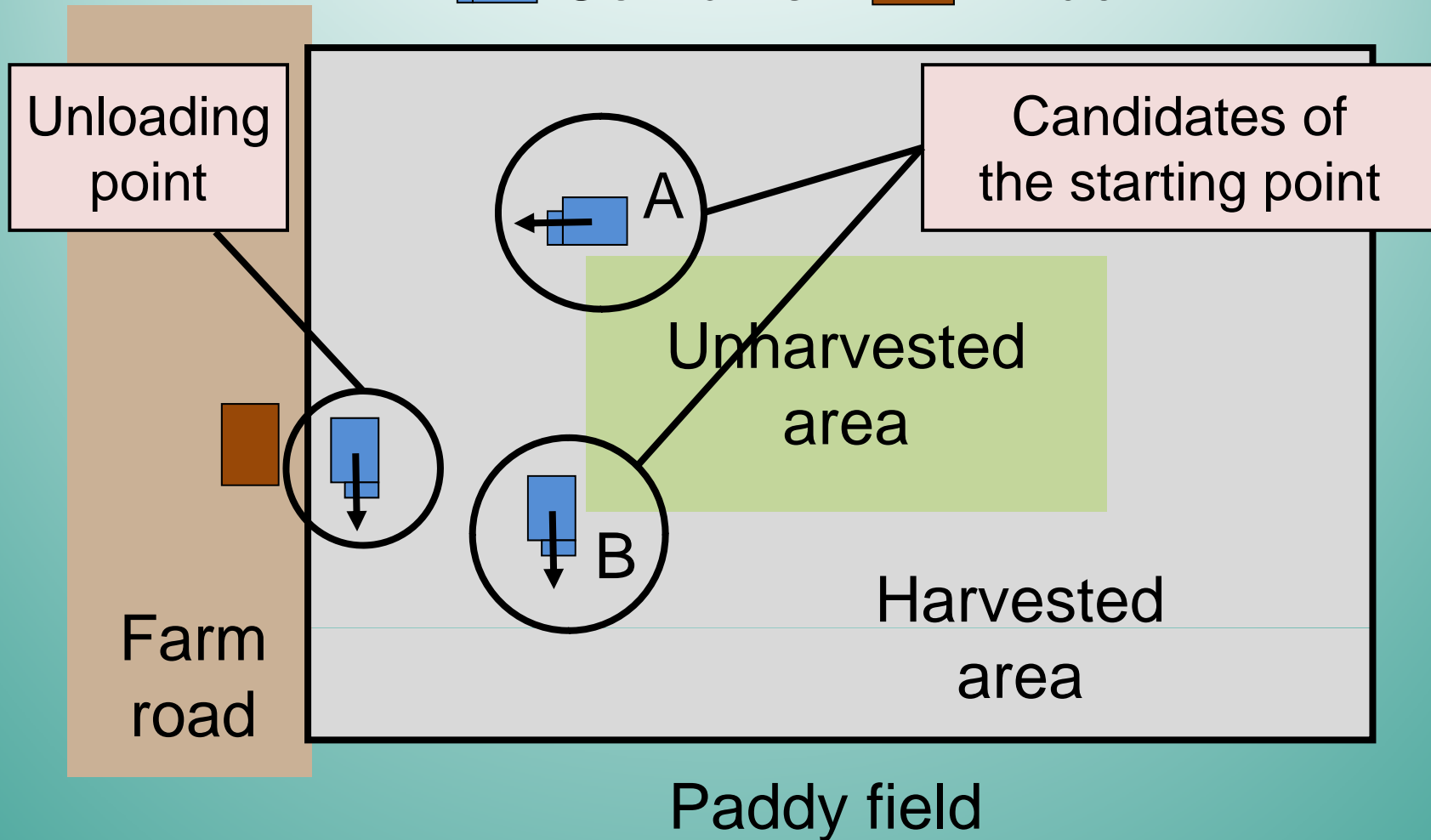
Planning path
to the unloading point

Harvesting pathway

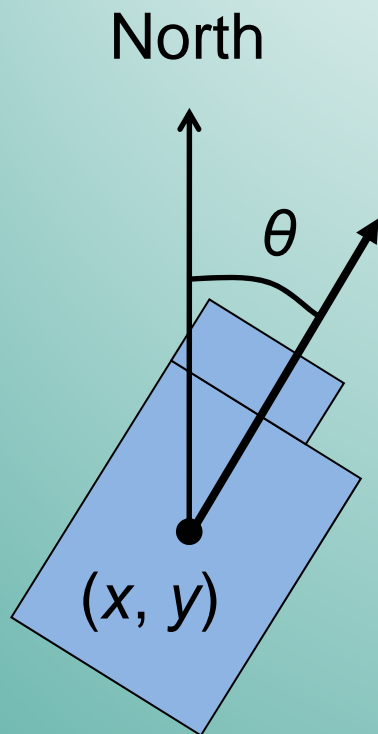


Starting point of unloading task

←  :Combine  :Truck



State of combine

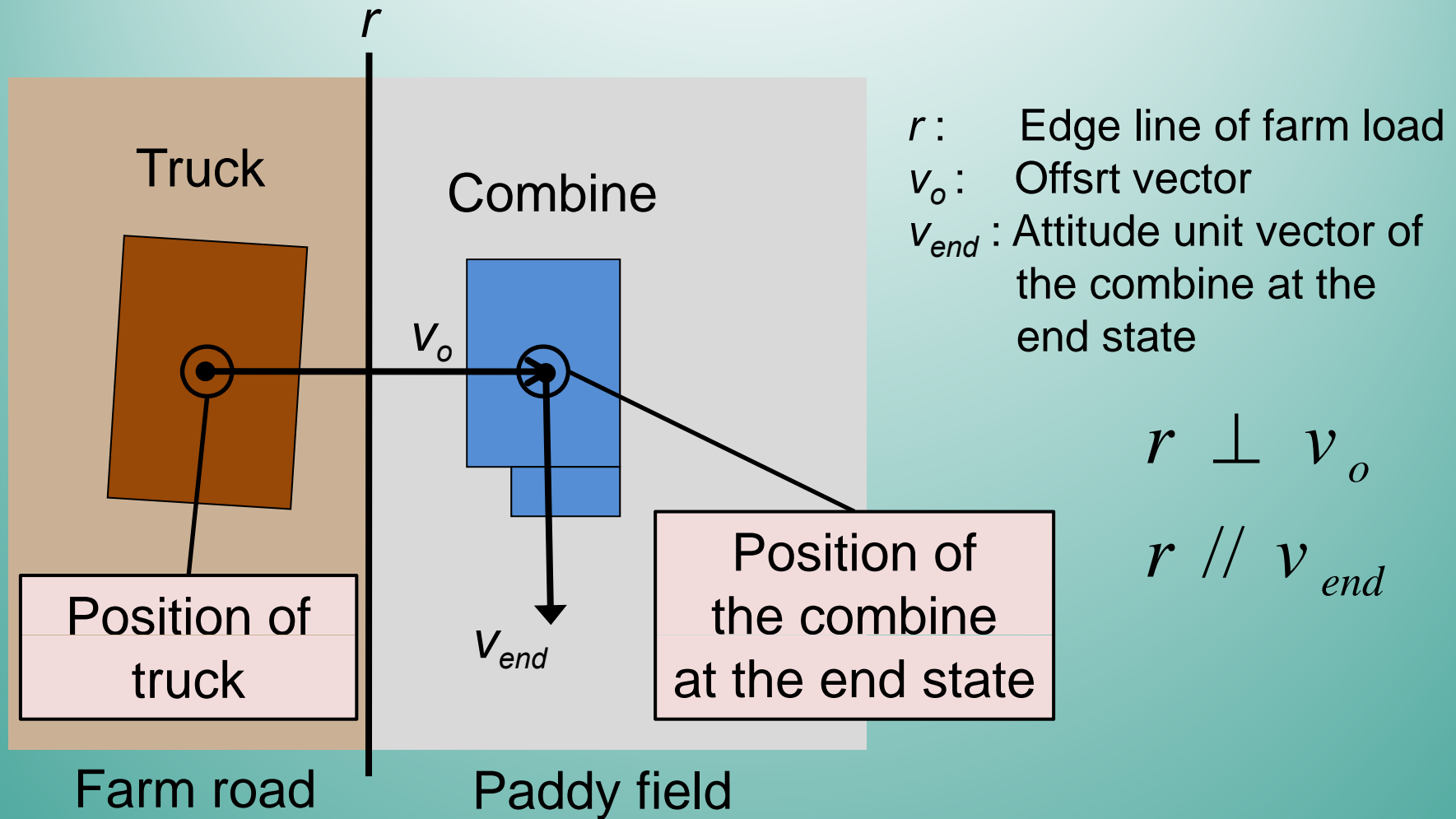


- The state of combine is described by the position (x, y) and attitude (θ) .
- (x, y) are measured by RTK-GPS and θ is measured by GPS compass.

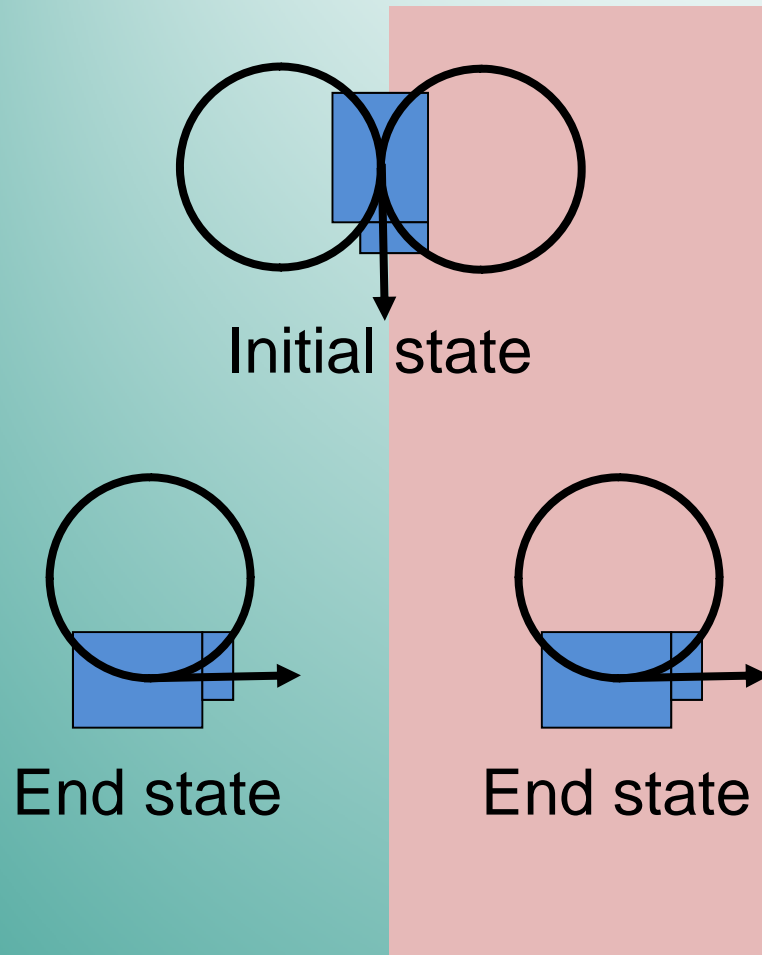
Path generation

- Our path planner generates path by using initial state and end state of the combine.
- The initial state is the state of the combine at the starting point of unloading task (set by using RTK-GPS and GPS compass).
- The end state is the state of the combine at the unloading point (set according to the position of the track).

One possible manner to set end state

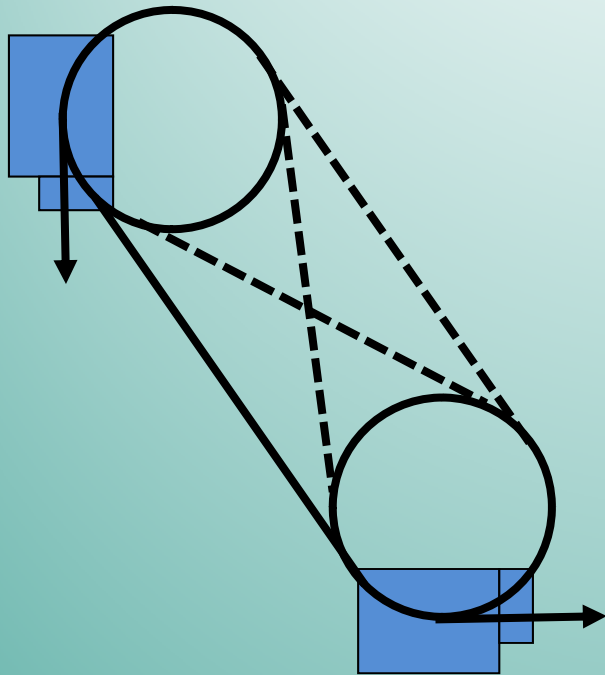


Path generation: Step 1



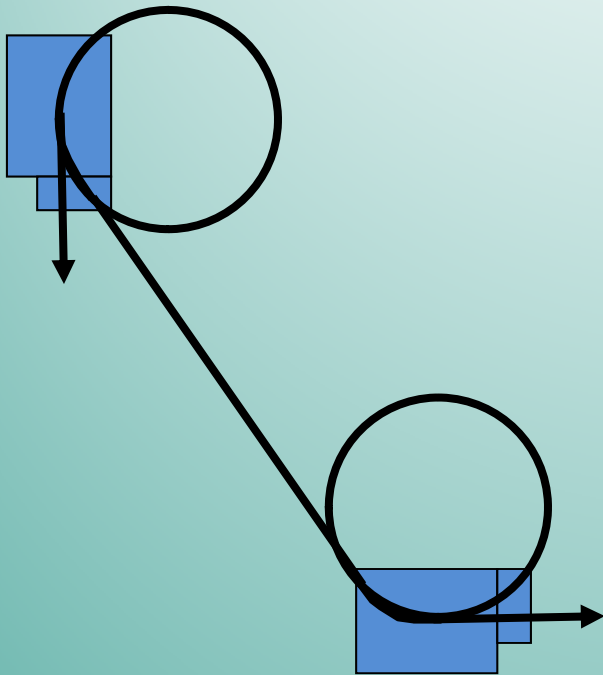
- Two circles with a constant radius are generated.
- The radius of circles is set equal to the expected turning radius of the combine.
- Each circle is set to have the posture vector of the combine as its tangent vector.

Path generation: Step 2



- Common tangent of the two circle is generated.
- We assumed that two circles neither intersect nor contact each other.
- The common tangent is properly selected among four candidates according to the initial state and the end state.

Path generation: Step 3

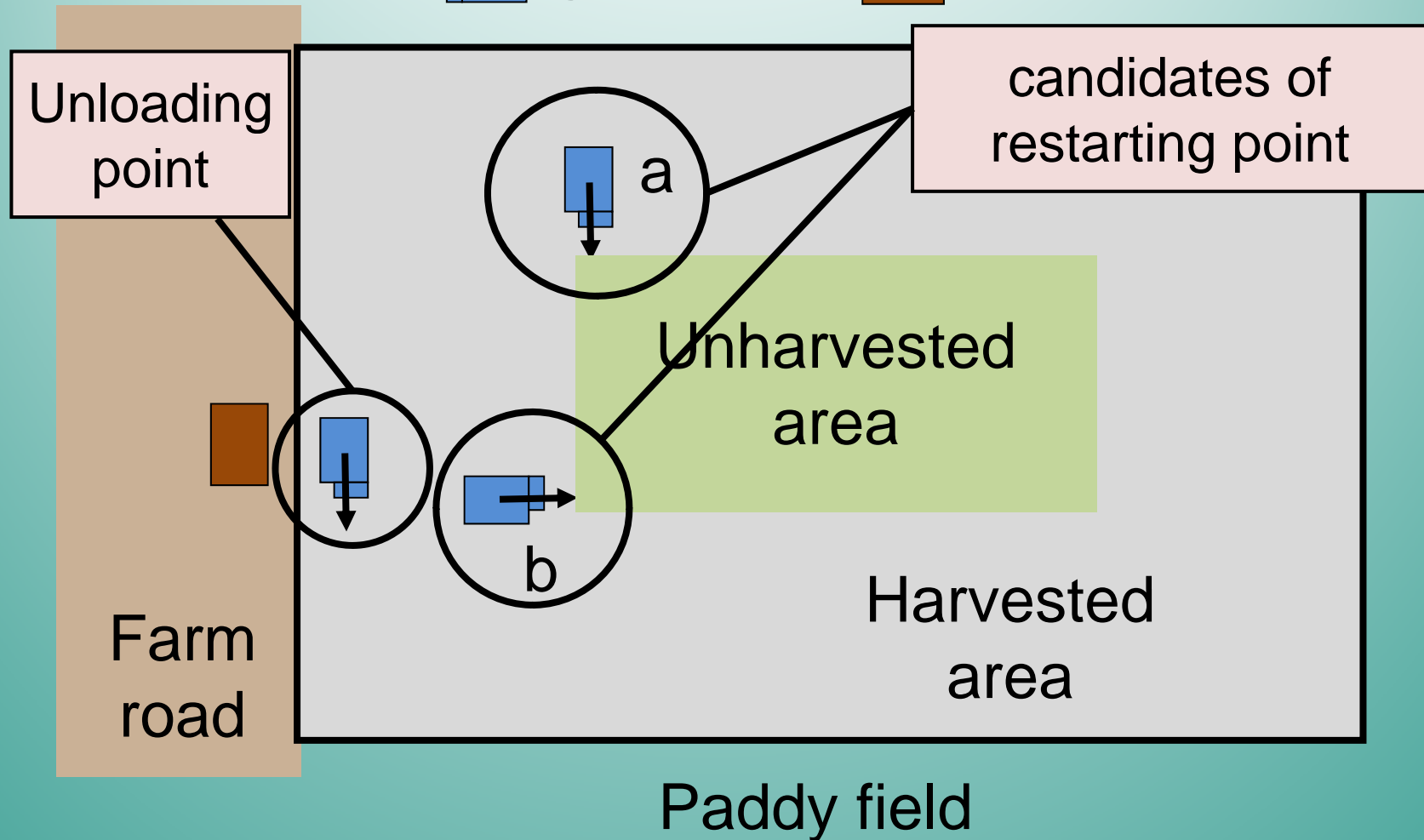


- The path is generated by using two circles and their common tangent.
- In the generated path, two circular arcs and straight line are connected smoothly.

Planning path
to the restarting point of
harvesting

Restarting point

← Combine Truck



How to generate return path

- Return path to the restarting point of harvesting is generated in the same way as the path to the unloading point is generated.
- The initial state is the state of the combine at the unloading point (set by using RTK-GPS and GPS compass).
- The end state is the state of the combine at the restarting point (set according to the position of the corner of harvested area).

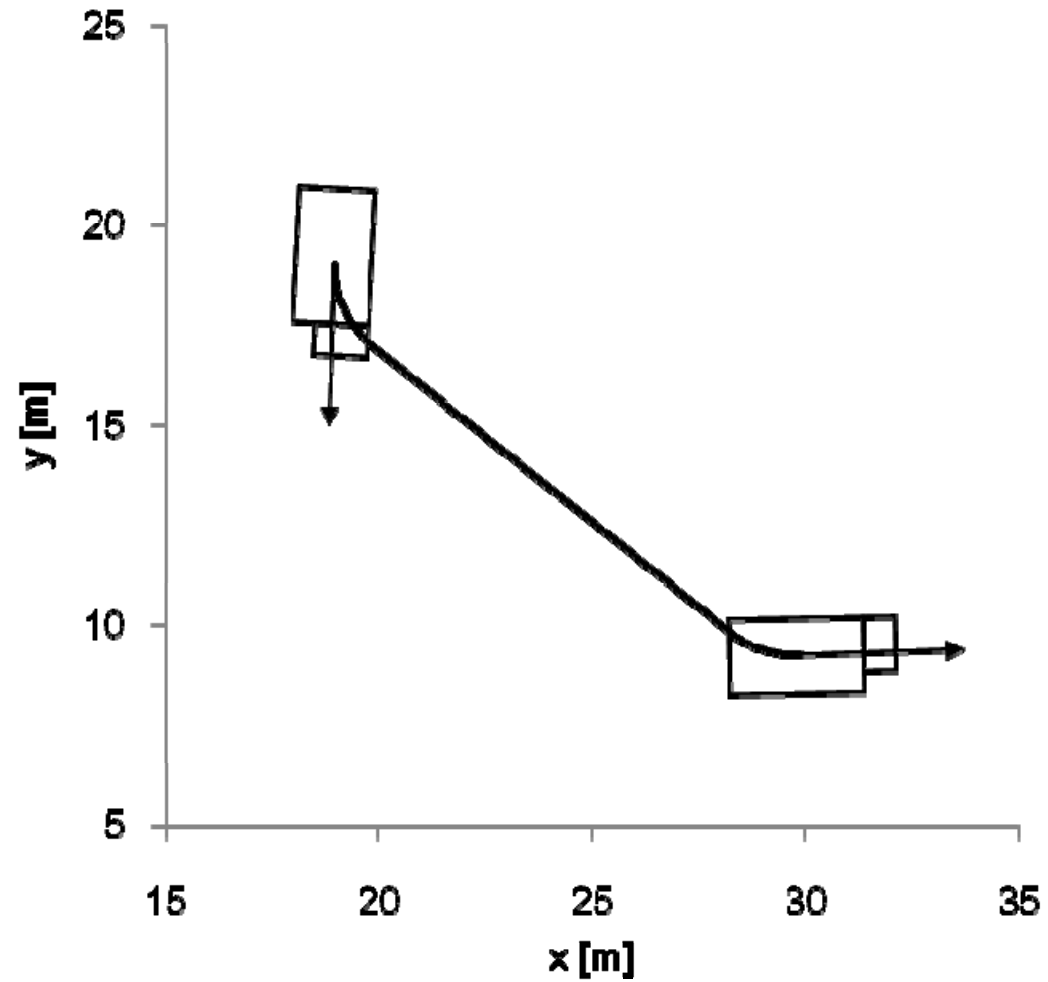
Restarting point selection

- The path planner has to select the restarting point among two candidates.
- The path planner compares the lengths of the paths to the two candidates of the restarting point.
- The path planner selects the restarting point with shorter path.

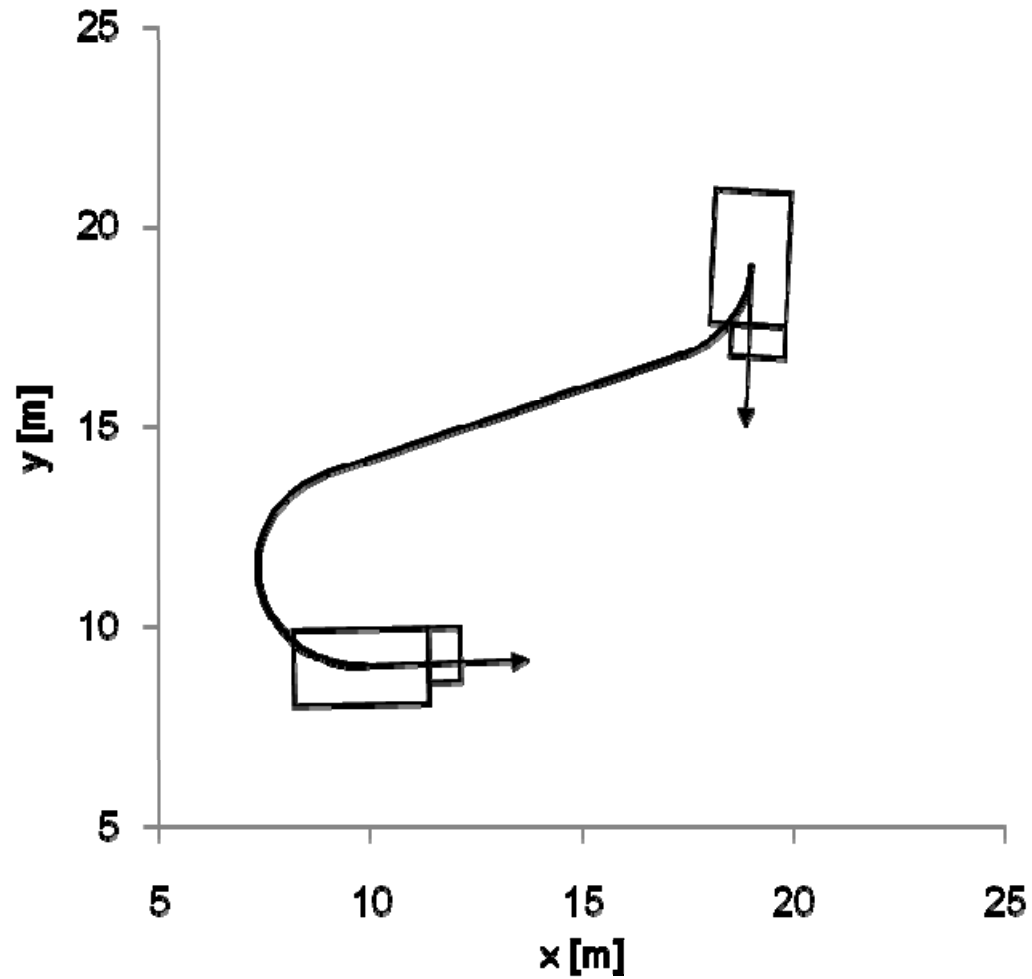
Results

-Computer Simulation-

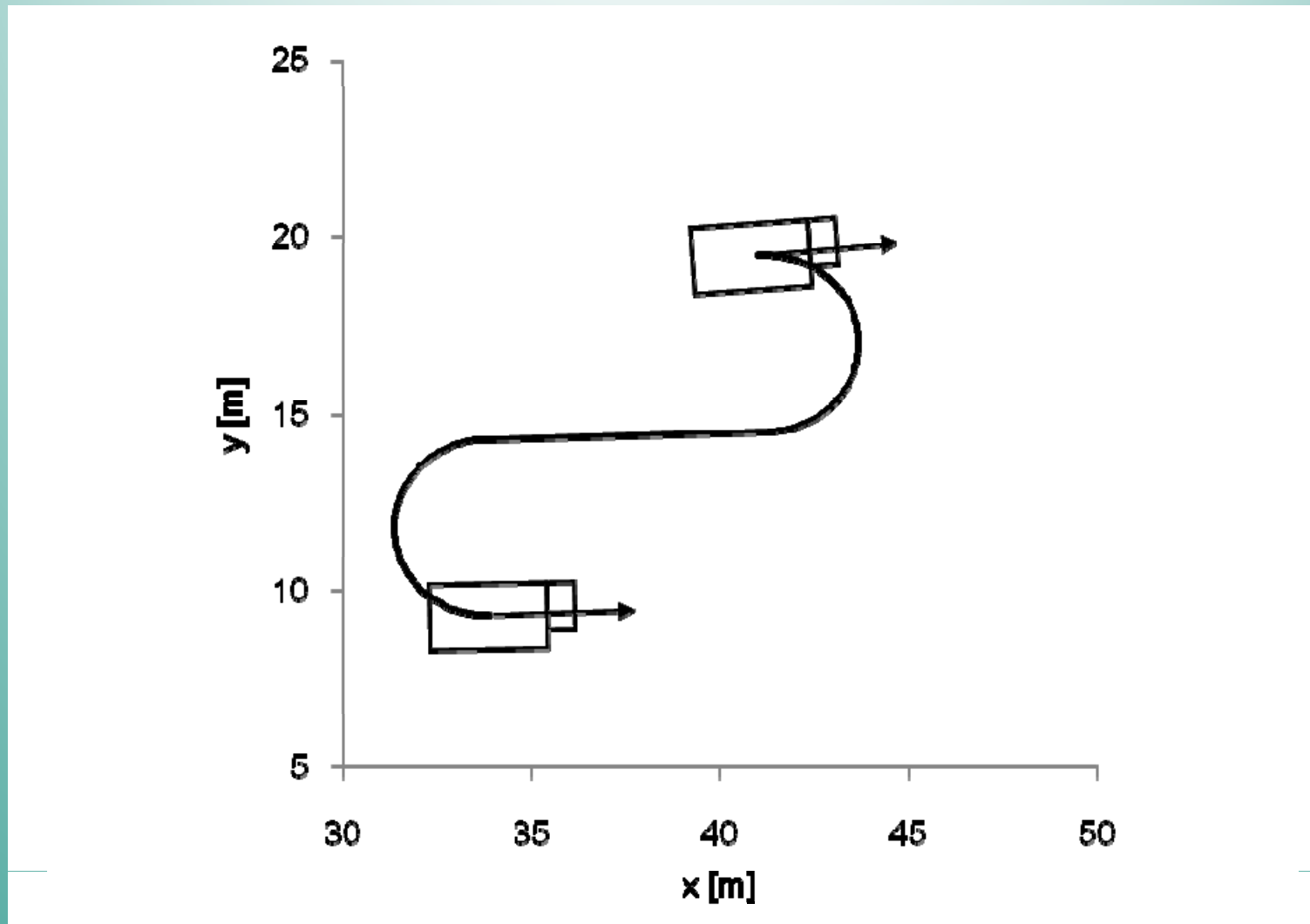
Path to the unloading point (1)



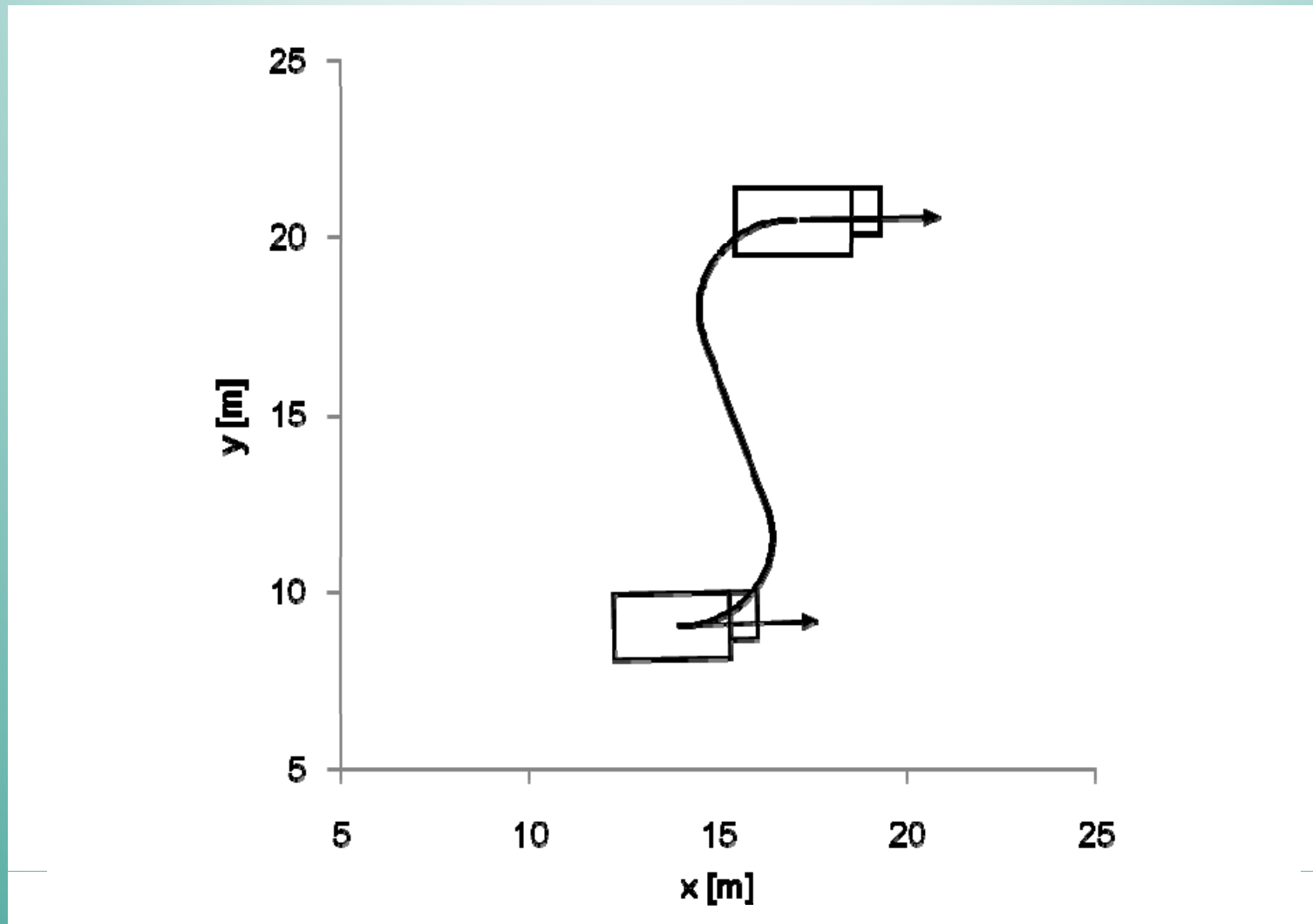
Path to the unloading point (2)



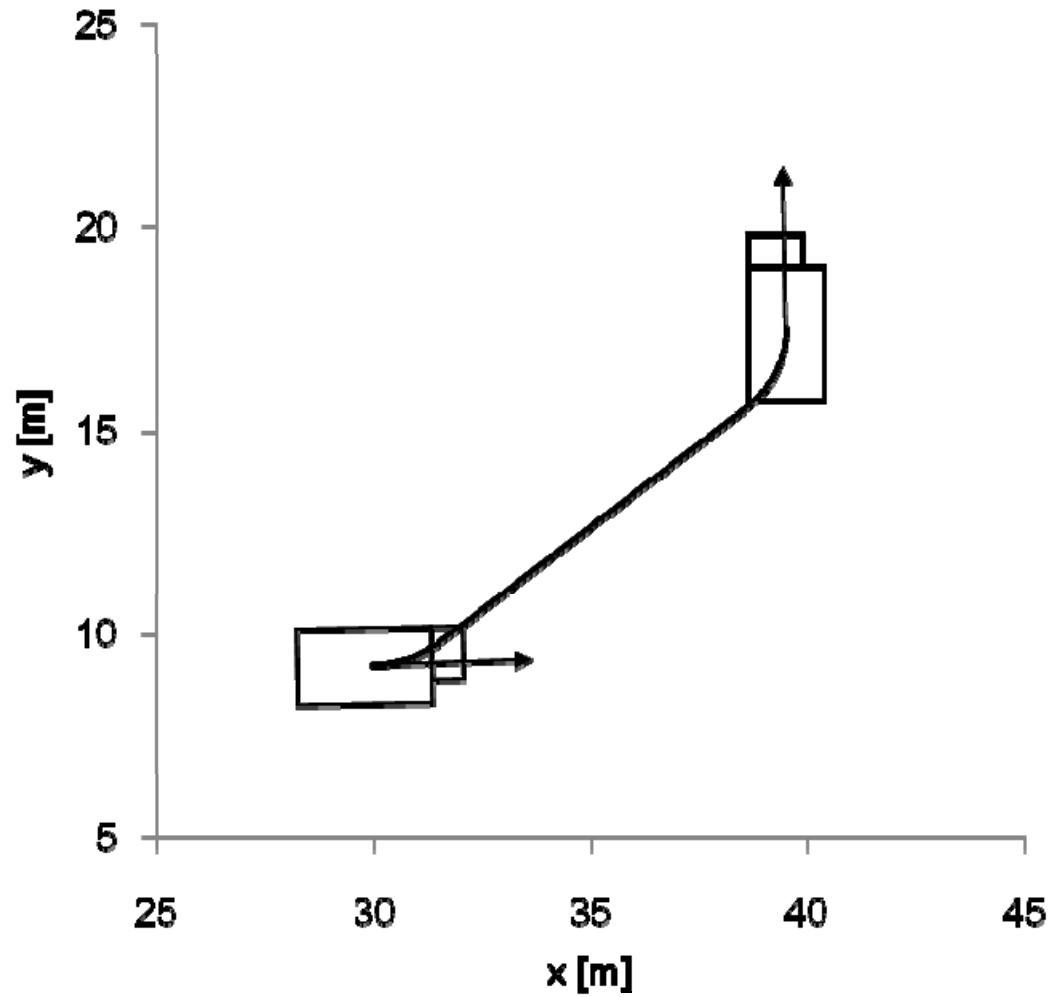
Path to the unloading point (3)



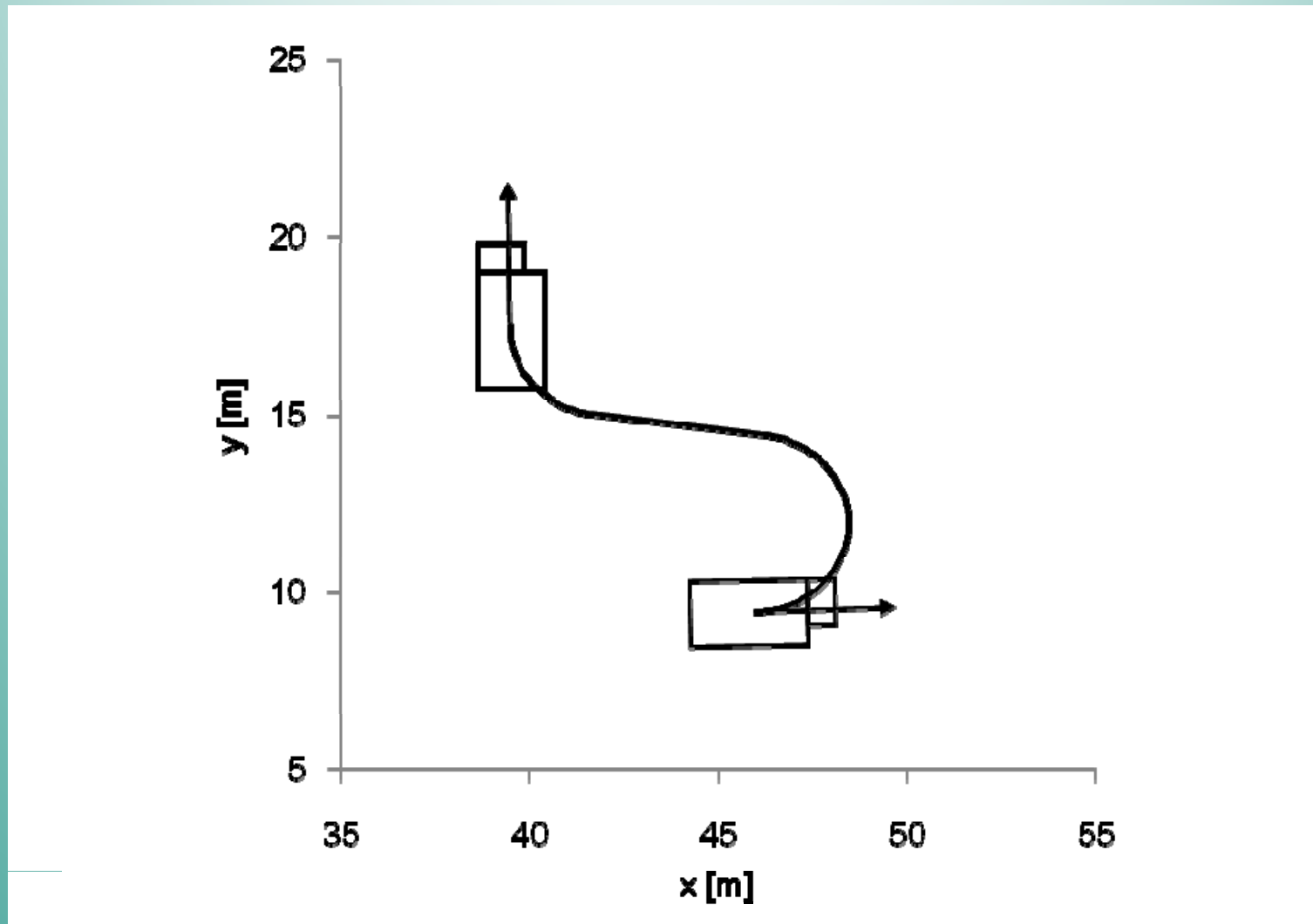
Path to the restarting point (1)



Path to the restarting point (2)



Path to the restarting point (3)



Conclusion (1)

- We developed path planner for unloading task of autonomous head-feeding combine.
- Under several prerequisites, the path generated by our planner prevents autonomous combine from both trampling down the unharvested crops and running out of paddy field.

Conclusion (2)

- The results of the simulation show that our proposing path planner could properly generate path according to the initial state and the end state of the combine.
- Backward movement of the combine is to be considered for more efficiency.

Conclusion (3)

- Toward actual use of the path planner, we need to develop method to decide when to start unloading task.
- We are to equip our path planner to the autonomous head-feeding combine and execute field test to evaluate the performance of the path planner in the field.

Acknowledgement

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Tank you for your attention!

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