Paper Review: Ground-level Mapping And Navigating for Agriculture Based on IoT And Computer Vision

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Submitted to- Annajiat Alim Rasel (**AAR**)

Summary

Motivation/purpose/ aims/hypothesis

Contribution

Methodology

Conclusion

Summary

Motivation/purpose/ aims/hypothesis

•Enhance agriculture mapping
•Combine IoT and computer vision
•IoT benefits precision agriculture

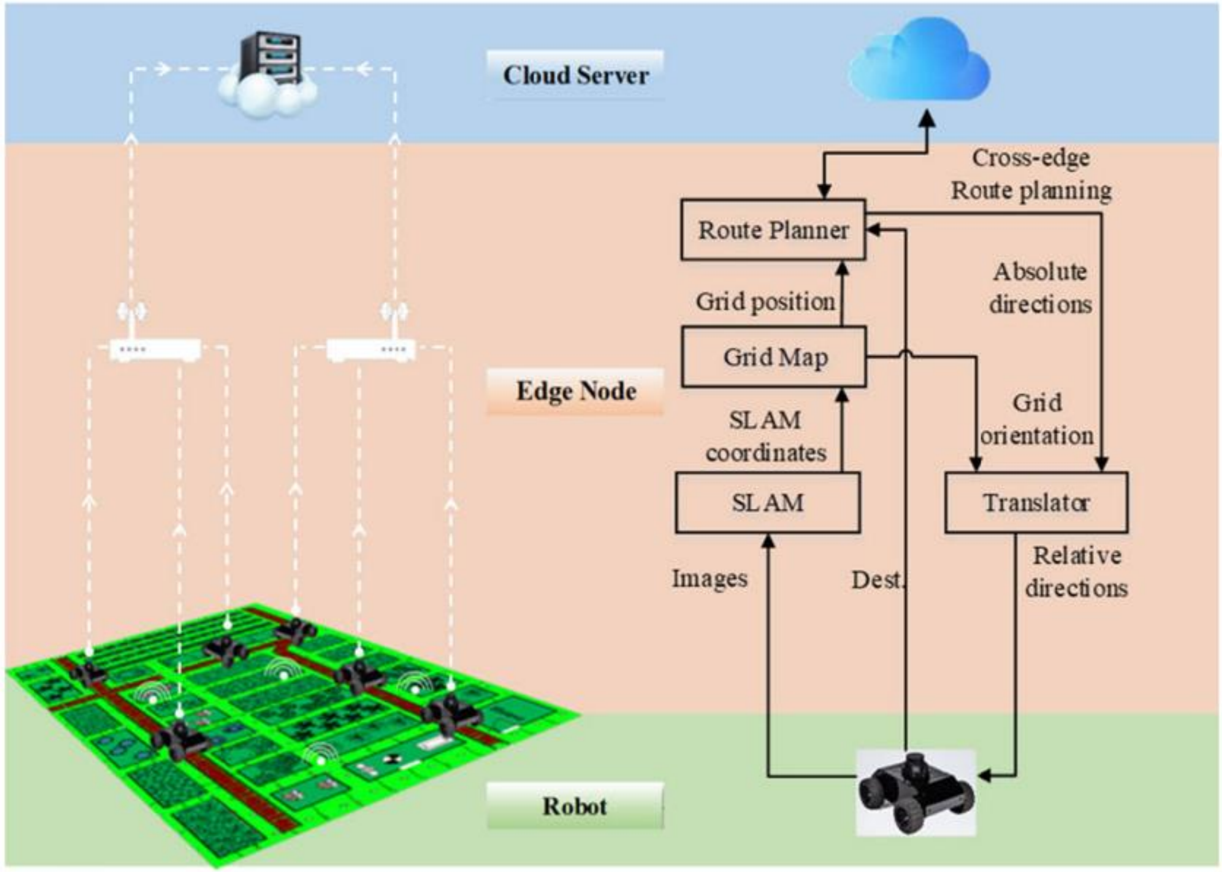


FIGURE 1. The IoT architecture of Cloud-Edge-Robot.

Summary

Contribution

- IoT-based mapping (Fig. 3)
- Computer vision and edge computing (Fig. 4)
- Advancing precision agriculture (Fig. 5)

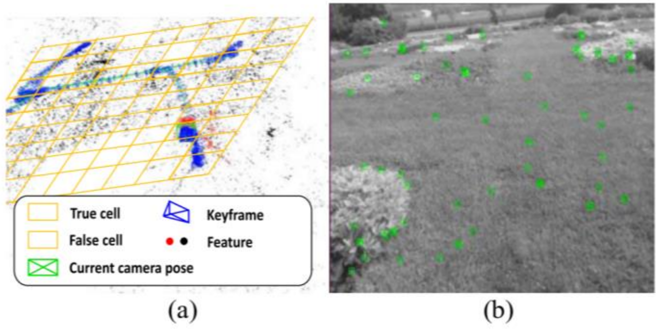
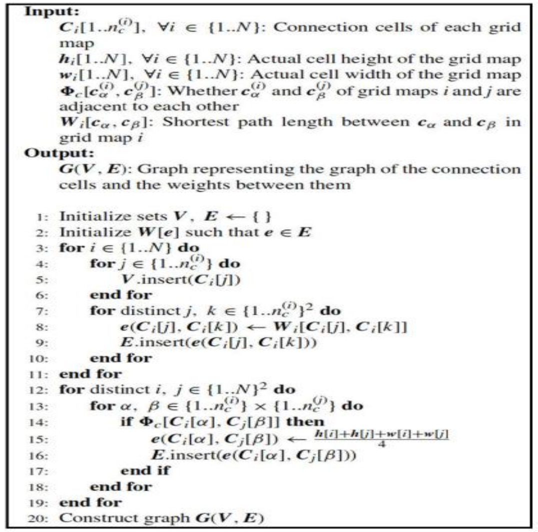


FIGURE 3. a) A demonstration of mn-scaled meshing with SLAM map and b) real-time farm view.



Input:
$C_i[1..n_c^{(i)}]$, $\forall i \in \{1..N\}$: Connection cells of each grid map
$h_i[1..N]$, $\forall i \in \{1..N\}$: Actual cell height of the grid map
$w_i[1..N]$, $\forall i \in \{1..N\}$: Actual cell width of the grid map
$\Phi_c[c_\alpha^{(i)}, c_\beta^{(j)}]$: Whether $c_\alpha^{(i)}$ and $c_\beta^{(j)}$ of grid maps i and j are adjacent to each other
$W_i[c_\alpha, c_\beta]$: Shortest path length between c_α and c_β in grid map i
Output:
$G(V, E)$: Graph representing the graph of the connection cells and the weights between them

```
Initialize sets V, E ← { }
Initialize W[e] such that e ∈ E
for i ∈ {1..N} do
    for j ∈ {1..n_c^(i)} do
        V.insert(C_i[j])
    end for
    for distinct j, k ∈ {1..n_c^(i)}^2 do
        e(C_i[j], C_i[k]) ← W_i[C_i[j], C_i[k]]
        E.insert(e(C_i[j], C_i[k]))
    end for
end for
for distinct i, j ∈ {1..N}^2 do
    for α, β ∈ {1..n_c^(i)} × {1..n_c^(j)} do
        if Φ_c[C_i[α], C_j[β]] then
            e(C_i[α], C_j[β]) ← (h[i]+h[j]+w[i]+w[j])/4
            E.insert(e(C_i[α], C_j[β]))
        end if
    end for
end for
Construct graph G(V, E)
```

FIGURE 5. Route planning algorithm based on the Mesh-map.

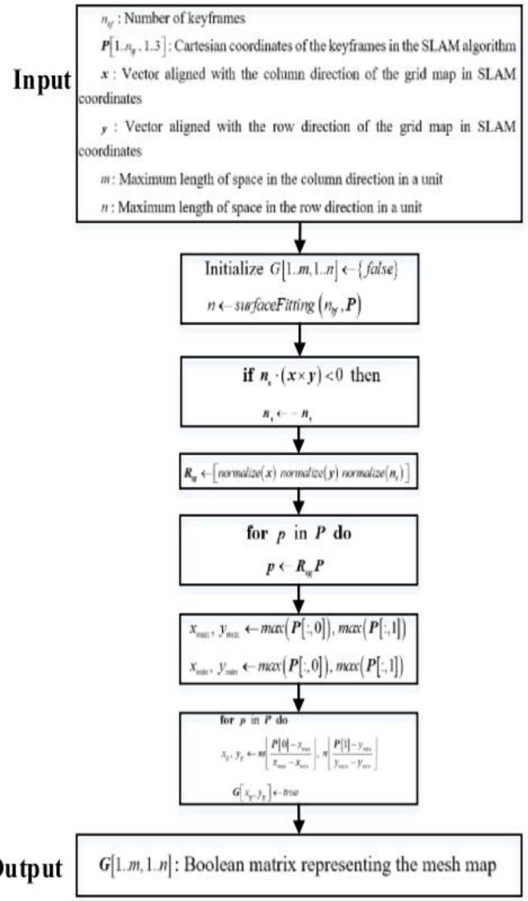
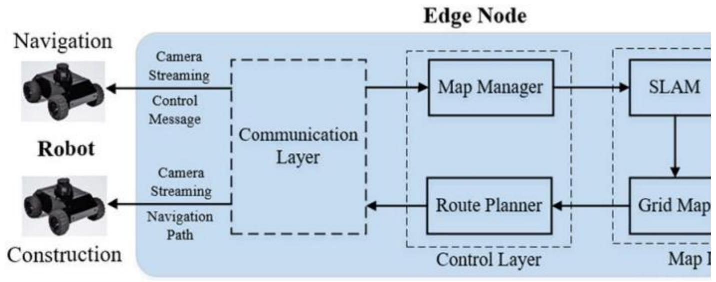


FIGURE 4. mn-Scaled Meshing algorithm.

Summary

Methodology

- Monocular cameras, SLAM, mesh maps (Figs. 2, 5)
- Accuracy, CPU usage, localization
- experiments (Figs. 9, 12)
- Real-time mapping for precision agriculture(Fig. 8)



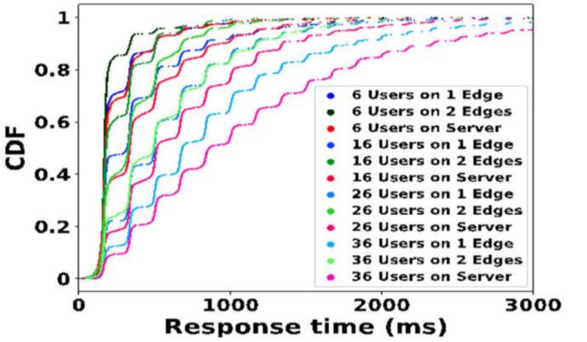


FIGURE 12. The CDF of the time intervals between responses. Note: User means a working robot.

Input:

$C_i[1..n_c^{(i)}]$, $\forall i \in \{1..N\}$: Connection cells of each grid map

$h_i[1..N]$, $\forall i \in \{1..N\}$: Actual cell height of the grid map

$w_i[1..N]$, $\forall i \in \{1..N\}$: Actual cell width of the grid map

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    end for
end for
for distinct i, j ∈ {1..N}^2 do
    for α, β ∈ {1..n_c^(i)} × {1..n_c^(j)} do
        if Φ_c[C_i[α], C_j[β]] then
            e(C_i[α], C_j[β]) ← (h[i]+h[j]+w[i]+w[j])/4
            E.insert(e(C_i[α], C_j[β]))
        end if
    end for
end for
Construct graph G(V, E)
```

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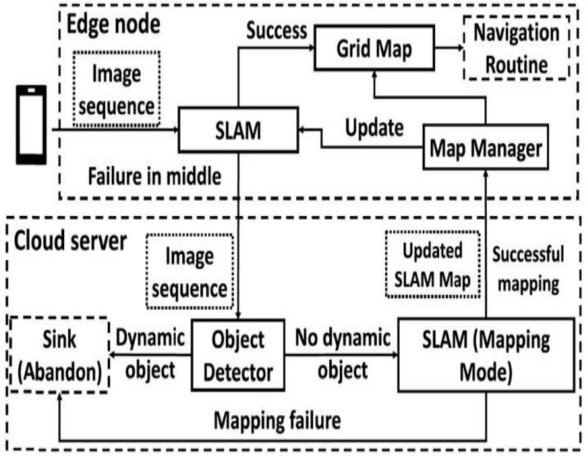


FIGURE 9. The flowchart of map maintenance.

Summary

TABLE 4. Results from the accuracy experiment.

Cell length (approximate) (cm)	30	60
Localization success frequency (%)	84.7	89.3
RMSE (cm)	19.5	0
Maximal error (cm)	36.9	0
Orientation accuracy (%)	100	100

Note: Orientation includes 8 directions separated by 45 degrees.

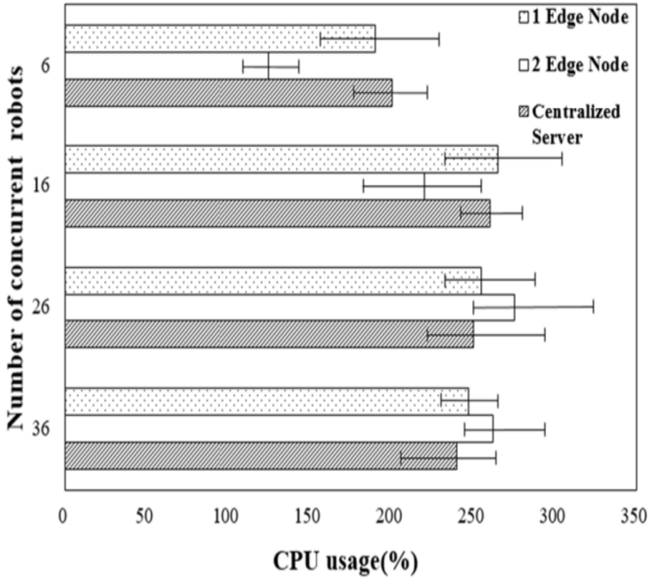
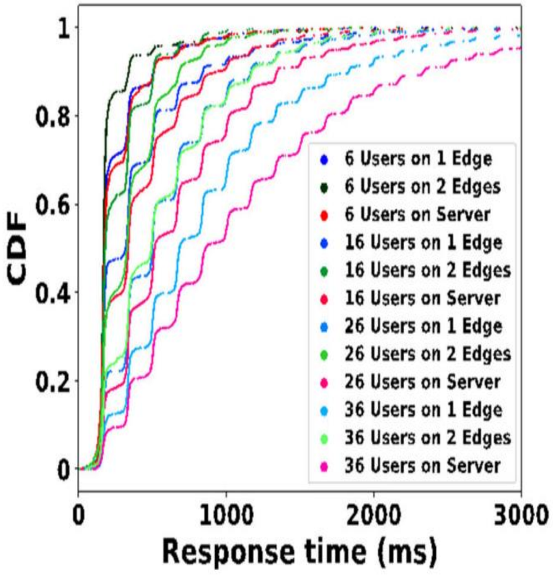


FIGURE 13. CPU usages in each experiment configuration.



GURE 12. The CDF of the time intervals between responses. Note: User eans a working robot.

Conclusion

- High accuracy (Table 4).
- Efficiency of edge computing (Fig. 13).
- Real-time data and map updates (Fig. 12).

Limitations

Limitation 1

Planar terrain assumption

Limitation 2

SLAM technology limitations

Synthesis

Future Applications

Environmental Monitoring

Smart Cities

Disaster Response

Exploration & Mapping

Versatile Industries

Overcoming Limitations

Enhancing Adaptability

Reference: Wei Zhao, Xuan Wang, Bozhao Qi, & Troy Runge. (2020). Ground-Level Mapping and Navigating for Agriculture Based on IoT and Computer Vision. *API* (Digital Object Identifier 10.1109/ACCESS.2020.3043662).