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A high precision visual localization sensor and its working methodology for an indoor mobile robot

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Key words: Mobile robot, Localization sensor, Visual localization, Infrared-reflective marker, Embedded system

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Motivation

- With the rapid development of robot techniques and an apparent urgent demand from the society, the indoor mobile robot will have a wide range of applications and provide services in diverse areas, such as transport, entertainment, and as a companion.

- Rapid and accurate autonomous localization is essential for the completion of these intelligent services. However, the traditional methods by themselves have low accuracy and poor robustness.

- Therefore, we design a high precision visual localization sensor for an indoor mobile robot.

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Method

- First, the hardware system of the localization sensor is developed.

- Second, we design a novel kind of infrared-reflective artificial marker whose characteristics can be extracted by the acquisition and processing of the infrared image. In addition, a confidence calculation method for marker identification is proposed to obtain the probabilistic localization results.

- Finally, the autonomous localization of the robot is achieved by calculating the relative pose relation between the robot and the artificial marker based on the perspective-3-point (P3P) visual localization algorithm.

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Major results

- Experimental results of marker identification and angle test are shown in Tables 1 and 2.

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Table 1 Experimental results of marker identification

Number of markers	Correct number	Accuracy	Mean elapsed time (ms)
200	192	96%	87

Table 2 Experimental results of angle test

Number	Real angle (°)	Output angle (°)	Measurement deviation (°)	Confidence
1	0	0.31	−0.31	0.94
2	30	29.12	0.88	0.92
3	60	62.38	−2.38	0.87
4	90	88.57	1.43	0.90
5	120	123.44	−3.44	0.84
6	150	146.82	3.18	0.85
7	180	181.03	−1.03	0.91
8	210	213.11	−3.11	0.85
9	240	239.65	0.35	0.94
10	270	269.35	0.65	0.93
11	300	301.98	−1.98	0.88
12	330	330.36	−0.36	0.94
13	360	2.23 (362.23)	−2.23	0.87

Major results (Cont'd)

- Experimental results of position test are shown in Table 3.

Table 3 Experimental results of position test

Number	Real position (cm)			Output position (cm)			Measurement deviation (cm)			Confidence,
	X_R	Y_R	Z_R	X_M	Y_M	Z_M	ΔX	ΔY	ΔZ	$P(S)$
1	−50.00	−50.00	260.00	−49.34	−49.19	261.17	−0.66	−0.81	−1.17	0.94
2	−50.00	−40.00	260.00	−51.63	−41.02	258.71	1.63	1.02	1.29	0.88
3	−50.00	−30.00	260.00	−51.29	−28.87	260.80	1.29	−1.13	−0.80	0.91
4	−50.00	−20.00	260.00	−48.15	−20.93	259.07	−1.85	0.93	0.93	0.88
5	−50.00	−10.00	260.00	−49.16	−11.79	261.17	−0.84	1.79	−1.17	0.88
6	−50.00	0.00	260.00	−51.56	1.80	259.12	1.56	−1.80	0.88	0.86
7	−50.00	10.00	260.00	−48.95	8.63	261.40	−1.05	1.37	−1.40	0.89
8	−50.00	20.00	260.00	−49.05	19.86	261.12	−0.95	0.14	−1.12	0.95
9	−50.00	30.00	260.00	−50.56	30.44	258.76	0.56	−0.44	1.24	0.95
10	−50.00	40.00	260.00	−51.27	38.77	260.06	1.27	1.23	−0.06	0.92
11	−50.00	50.00	260.00	−51.13	49.49	259.03	1.13	0.51	0.97	0.94

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Conclusions

- The proposed localization system can not only provide a sufficient number of markers but also reduce the interference of illumination variation and observation angle on localization accuracy, which improves the robustness of the localization system efficiently.

- The precision of the designed sensor is ±1.94 cm for position localization and ±1.64° for angle localization.

- The proposed visual localization sensor system satisfies the requirements of accurate autonomous indoor robot navigation and provides a novel indoor localization method for a home service robot.

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