1. The Improved Locating Algorithm of Particle Filter Based on ROS Robot

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Abstract: This paperanalyzes basic theory and primary algorithm of the real-time locating system and SLAM technology based on ROS system Robot. It proposes improved locating algorithm of particle filter effectively reduces the matching time of laser radar and map, additional ultra-wideband technology directly accelerates the global efficiency of FastSLAM algorithm, which no longer needs searching on the global map. Meanwhile, the re-sampling has been largely reduced about 5/6 that directly cancels the matching behavior on Roboticsalgorithm. © Published under licence by IOP Publishing Ltd. (8 refs.)

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The Improved Locating Algorithm of Particle Filter Based on **ROS Robot**

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Abstract. This paperanalyzes basic theory and primary algorithm of the real-time locating system and SLAM technology based on ROS system Robot. It proposes improved locating algorithm of particle filter effectively reduces the matching time of laser radar and map, additional ultra-wideband technology directly accelerates the global efficiency of FastSLAM algorithm, which no longer needs searching on the global map. Meanwhile, the re-sampling has been largely reduced about 5/6 that directly cancels the matching behavior on Roboticsalgorithm.

1. Introduction

With rapid popularization of intelligent robot, mobile Roboticstechnology attracts much attention. When intelligent Roboticsfaces complex and uncertainties of terrain environment [1], how to determine the position of mobile robot, how to avoid the obstacle effectively, and provide good map are significant for living quality improvement. As LEGO Company launches the Roboticsunits, the educational robots, such as Makeblock, Ollie, Romibo, Cubelets, Ozobot appear subsequently. The toy robots, such as Roboblock, PLEO, Sphero, MIP and NAO, the turtlebot, Compass Q2, MobileRobots, RoboCup and other mobile Roboticsplatforms for campus and research units' studying and researching as well as the robots are entering people' daily life. The Boston-power has issued the fourfooted RoboticsSpot Mini, and Atlas humanoid biped robot, which not only develops on the industrial robot, but also on domestic robot. Such as, iRoboticssmart sweeper Robotics^[2] that has already occupied lots of share in international market. V-BOT, Midea, ECOVACS, tomefon, Philips and other companies have already entered this field. In domestic, the mobile machine starts relatively late [3]. Ausone robots developed the cross-country Roboticsplatform, DFROBOTICSlaunched the HCR household all-around mobile platform, and Suzhou Soya produced the Roch Roboticsplatform with other robots. At present, many service mobile robots have been popularized on the market. SLAMTEC ZEUS general service Roboticsplatform researched and developed by Silan Technology can make intelligent advertisement, deliver drinks, and accompany family members etc. The emergence of mobile robots accelerated the development of domestic industries, which not only increases the profit but also obtains many outstanding achievements.

The navigation of mobile Roboticssenses the environment and its own state through sensors to achieve autonomous movement [4] with purpose. Locating and path planning are unavoidable problems for mobile robots. The mobile Roboticsexplores on known and unknown maps to navigate by its inner sensors, including camera, 9-shaft sensor, rotary colder, specific road sign identification point [5] etc. Absolute positioning and relative positioning [6] are frequently-used positioning forms. Meanwhile, the construction of environment map helps the mobile Roboticsto plan an optimal path from starting point to target point in set environment model with obstacles.

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2. ROS Mobile Robotics Navigation Technology

2.1. Monte Carlo Localization (MCL)

The robotics uses sensor that can measure the distance between the robot's various directions and nearest obstacles. At each time point, the robotics can get measured values of the laser sensor. In occupying grip maps, the Robotics acquires the map information that matches the reading of laser sensor. Suppose the estimated robot's position information is $[x,y,\theta]$ (x and y is the coordinate).

 θ is the robot's orientation), the recorded robotics position information is consistent with multielement Gauss distribution, and the particles sampled by which are used to show the robotics position [7]. The Monte Carlo localization method can be described as following four steps:

Monte Carlo (Monte Carlo Localization) algorithm can effectively initialize current position and posture of the robot. The static machine can directly access the constructed map and positioning the robotics by matching based on the map and data returned by the sensor.

If the robot's initialized posture is uncertain, MCL will try to positioning the robotics without knowing the robot's initial position. The algorithm assumes that the robotics may have the same probability anywhere in the free space of current region, and produces uniformly distributed particles within such space. After many updates, all the particles should converge to correct robotics posture, and the laser scanning should be closely aligned with the map's outline.

2.2. FastSLAM Localization

2.2.1. Pose Estimation. FastSLAM also uses particle filter to estimate the posterior probability of $P(S^t, \lambda | Z^t, U^{t-1}, n^t)$, marked as S_t . Each particle $S_t^i \in S_t$ shows the pose path approximate of the robot.

(Among which, i is the serial number of particles in the collection, λ is the number of environmental features, Z^t is the pose S_t observation data of external robotics sensor at the time of t,

 U^{t-1} is the input data of robot's internal mile-meter sensor moving from S_{t-1} to S_t at the time of t-1.

As to calculate the particle set S_t at the time of t, we need to know S_{t-1} , environment observation information z_t and control input information u_{t-1} . In the S_{t-1} , each particle obtains the robot's approximate pose at the time of t by estimation combined with the motion model; Then, add the robot's pose path estimation at the time of t into temporary particle set. Suppose the function is sampling by proposal distribution $P(S^t, \lambda | Z^t, U^{t-1}, n^t)$, the re-sampling is according to importance weight of each particle. The new particle set is all sampled by temporary particle set, which totally has N_p particles.

$$P(S^{t},\lambda|Z^{t},U^{t-1},n^{t}) = P(S^{t}|Z^{t},U^{t-1},n^{t}) \prod_{k=1}^{K} P(\lambda_{k}|S^{t},Z^{t},U^{t-1},n^{t})$$
(2.1)

$$w_{t}^{i} = \frac{t \arg et _distributi \ on}{proposal \ distributi \ on} = \frac{P(S^{t,i} | Z^{t}, U^{t-1}, n^{t})}{P(S^{t,i} | Z^{t-1}, U^{t-1}, n^{t-1})}$$
(2.2)

Same as the particle filter, the large the particle number, the obtained particle set is closer to real posterior probability distribution $P(S^t|Z^t, U^{t-1}, n^t)$.

2.2.2. Landmark Estimation.Landmarks are estimated by above formula (in particle set, each particle calculates the next landmark's position under current condition by extended Calman filter. Therefore, the complete posterior probability of environmental landmark estimation in algorithm can be expressed as:

$$S^{t} = \{S^{t,i}; U_{1}^{i}, \sum_{1}^{i}, \dots, U_{k}^{i}, \sum_{k}^{i}\}$$
 (2.3)

(Among which, U_k^i is the mean value of number i th particle's environment landmark of number k, $\sum_{k=1}^{i}$ is the variance of number k th particle's environment feature λ_k , and λ_k uses Gauss distribution.)

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2.2.3. Ultra-wideband Integrated Positioning Method. Ultra-wideband (UWB) wireless positioning technology uses TDOA (Time difference of Arrival) or double flight time method (TW-TOF) positioning, and determines the mobile station by time difference received by multiple base stations.

UWB generally uses (Time Difference of Arrival) TDOA technology [8]. TDOA technology positioning to determine one point via three circles on the plane, and determine one point in the space via four circles. In the application, please note if there's barriers and interference of metals in transmission environment.

2.3. Improved Proposal Distribution Function

Determine the region, and the one with greater probability density according to UWB. Then, select the particle sample in the region, and calculate each particle's weight according to target distribution. Bring the observation model taken by UWB obtained

Robotics position in proposed distribution, and modify calculation formula of the weight, which effectively reduces the re-sampling time and reduce the particle number, and enables the robotics to match the map as well in high speed running for localization.

3. Localization Simulation Experiment

This paper designs several types of topographic maps as below, which are used to test the real effect of FastSLAM. Time the required time and re-sampling time for once map matching by multiple tests of solving the mean value. Observe whether mobile robotics processes map matching and record the required time. Comparing original algorithm of ROS, and distinguish them in blue.



Figure 3.1 map1: indoor short bottleneck testing map Figure 3.2 map2: indoor cube testing map

For convenience, the four maps are from four different regions on the same map, including Fig. 1, 3 as below, rectangles and squares. Without additional UWB technology, we initialize the particle swarm's location at the map center when testing, but the real position of the robotics is at in any place of the map.



Figure 3.3 map3: indoor long bottleneck testing mapFigure 3.4 map4: indoor rectangle testing map

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The re-sampling time is counted by tic, toc, and mobile robotics completes whole map matching during map matching time, which starts from the algorithm and terminates the whole time. When particle filter processes map pairing, the mobile robotics will has special action that rotating the original point. Record whether it happens, and the rotational time.

Map Type Required Time	Map 1	Map 2	Map 3	Map 4
Re-sampling Time	1.3s\6.3s	1.2s\6.5s	1.2s\6.2s	1.6s\7.3s
Map Matching Time	2.2s\8.4s	2.1s\7.7s	3.1s\8.2s	5.5s\11.6s
Map Matching Behavior	None\7.1s	None\6.3s	None\7.2s	None\9.1s

Table 1. Time of Different Types of Parameters

From Table 1, localization algorithm of improved particle filter can effectively reduce the matching time of radar and map so that the filter doesn't need global searching on the map, and whole map matching time is significantly shortened to more than a half. Meanwhile, the re-sampling time is significantly shortened about 5/6, which shows we can save the Map Matching time of the robot.

4. Conclusion

This paper propose an interesting improved algorithm that localization algorithm of improved particle filter can effectively reduce the matching time of radar and map so that the filter doesn't need global searching on the map. The localization simulation experiments demonstrates that the whole map matching time is significantly shortened to more than a half, which the re-sampling time is significantly shortened about 5/6 of old algorithm. The method will same the map matching time of the robot localization.

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References

- [1] J. van der Geer, J.A.J. Hanraads, R.A. Lupton, The art of writing a scientific article, J. Sci. Commun. 163 (2000) 51-59.
- [2] W. Strunk Jr., E.B. White, The Elements of Style, third ed., Macmillan, New York, 1979.
- [3] Reference to a chapter in an edited book:
- [4] G.R. Mettam, How to prepare an electronic version of your article, in: B.S. Jones, R.Z. Smith (Eds.), Introduction to the Electronic Age, E-Publishing Inc., New York, 1999, pp. 281-304.
- [5] C. D. Smith and E. F. Jones, "Load-cycling in cubic press," in Shock Compression of Condensed Matter-2001, AIP Conference Proceedings 620, edited by M. D. Furnish et al. American Institute of Physics, Melville, NY, 2002, pp. 651–654.
- [6] P.G. Clem, M. Rodriguez, J.A. Voigt and C.S. Ashley, U.S. Patent 6,231,666. (2001)
- [7] The Math WorksInc, Localize TurtleBot Using Monte Carlo Localization,https://cn.mathworks.com/help/robotics/examples/localize-turtlebot-using-montecarlo-localization.html,2015.
- [8] B Lonske, EV Doorn, S Ponnaluri A Bhat, Bureau of Justice Statistics, 2013.