A Systematic Review on Long-Term Localization and Mapping for Mobile Robots

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Planning

understand the state-of-the-art in long-term SLAM, understand the existent trends and gaps in long-term SLAM, answer all the research questions defined below

PICOC

- **Population:** mobile robots, autonomous vehicles
- **Intervention:** localization and mapping, SLAM
- **Comparison:**
- **Outcome:** long-term operation, lifelong autonomy, robust
- **Context:** continuous operation, service robots, industrial environments

Research Questions

1. which are the main strategies for accomplishing long-term operations with mobile robots
2. how to deal with varying conditions of the environment
3. how do autonomous robots deal with the dynamics of the environment
4. which are the main strategies to deal with the limited computational resources of a mobile robot on long-term operations

Keywords and Synonyms

Keyword   Synonyms

SLAM

autonomous vehicles

lifelong autonomy

localization and mapping

long-term operation

mobile robots

robust

(robot* OR vehicle*) AND ((locali* AND map*) OR "slam") AND ("long term" OR "life long" OR lifelong)

Sources

- ACM Digital Library (http://portal.acm.org)
- Dimensions (https://www.dimensions.ai/)
- El Compendex (http://www.engineeringvillage.com)
- IEEE Digital Library (http://ieeexplore.ieee.org)
- ISI Web of Science (http://www.isiknowledge.com)
- Scopus (http://www.scopus.com)

Selection Criteria

Inclusion Criteria:

Exclusion Criteria:

- E1: Index
- E2: Language
- E3: Subject area
- E4: Short papers
- E5: Gray, secondary, and tertiary literature
- E6: Availability
- E7: Dataset
- E8: Coverage
- E9: Scope

Quality Assessment Checklist

Questions:

- QE1: Does the paper have an updated state of the art on long-term localization and mapping?
- QE2: Is the methodology appropriate and detailed?
- QE3: Does the methodology consider both localization and mapping problems?
- QE4: Is the hardware and/or software used in the experiments detailed?
- QE5: Does the paper presents any kind of long-term experimental results?
- QE6: Does the paper presents comparative results with other methods and/or ground-truth data?
- QE7: Does the work's implementation and the data used in the experiments publicly available?
- QE8: Is the discussion of the results and conclusions appropriate and detailed?

Answers:

- Full compliance (QE3, QE5)

- Full compliance
- Partial compliance (QE3, QE5)
- Partial compliance
- No compliance

Data Extraction Form
- DE1: Long-term considerations
- DE2: Localization and mapping methods
- DE3: Type of localization
- DE4: Type of map
- DE5: Active perception
- DE6: Path planning
- DE7: Visual Teach & Repeat
- DE8: Multi-robot system
- DE9: Prior knowledge
- DE10: Computation architecture
- DE11: Online/Offline execution
- DE12: Environment
- DE13: Domain of the robot
- DE14: Sensory setup
- DE15: Performance measures
- DE16: Implementation repository
- DE17: Datasets used in the experiments
- DE18: Total traveled distance
- DE19: Total time interval

Conducting

Digital Libraries Search Strings
ACM Digital Library:

Title:((robot* OR vehicle*) AND ((locali* AND map*) OR "slam") AND ("long term" OR "life long" OR lifelong)) OR Abstract:((robot* OR vehicle*) AND ((locali* AND map*) OR "slam") AND ("long term" OR "life long" OR lifelong)) OR Keyword:((robot* OR vehicle*) AND ((locali* AND map*) OR "slam") AND ("long term" OR "life long" OR lifelong))

Dimensions:

(robot OR robots OR robotics OR vehicle OR vehicles) AND (((localize OR localization OR localizing OR localise OR localisation OR localising) AND (map OR maps OR mapping)) OR "slam") AND ("long term" OR "life long" OR lifelong)

El Compendex:

(((robot* OR vehicle*) AND ((locali* AND map*) OR "slam") AND ("long term" OR "life long" OR lifelong)) WN KY)

IEEE Digital Library:

("Document Title":robot* OR "Document Title":vehicle*) AND (("Document Title":locali* AND "Document Title":map*) OR "Document Title":"slam") AND ("Document Title":"long term" OR "Document Title":"life long" OR "Document Title":lifelong)

("Abstract":robot* OR "Abstract":vehicle*) AND (("Abstract":locali* AND "Abstract":map*) OR "Abstract":"slam") AND ("Abstract":"long term" OR "Abstract":"life long" OR "Abstract":lifelong)

("Index Terms":robot* OR "Index Terms":vehicle*) AND (("Index Terms":locali* AND "Index Terms":map*) OR "Index Terms":"slam") AND ("Index Terms":"long term" OR "Index Terms":"life long" OR "Index Terms":lifelong)

("Author Keywords":robot* OR "Author Keywords":vehicle*) AND (("Author Keywords":locali* AND "Author Keywords":map*) OR "Author Keywords":"slam") AND ("Author Keywords":"long term" OR "Author Keywords":"life long" OR "Author Keywords":lifelong)

("IEEE Terms":robot* OR "IEEE Terms":vehicle*) AND (("IEEE Terms":locali* AND "IEEE Terms":map*) OR "IEEE Terms":"slam") AND ("IEEE Terms":"long term" OR "IEEE Terms":"life long" OR "IEEE Terms":lifelong)

("INSPEC Controlled Terms":robot* OR "INSPEC Controlled Terms":vehicle*) AND (("INSPEC Controlled Terms":locali* AND "INSPEC Controlled Terms":map*) OR "INSPEC Controlled Terms":"slam") AND ("INSPEC Controlled Terms":"long term" OR "INSPEC Controlled Terms":"life long" OR "INSPEC Controlled Terms":lifelong)

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ISI Web of Science:

TS=((robot* OR vehicle*) AND ((locali* AND map*) OR "slam") AND ("long term" OR "life long" OR lifelong))

Scopus:

TITLE-ABS-KEY((robot* OR vehicle*) AND ((locali* AND map*) OR "slam") AND ("long term" OR "life long" OR lifelong))

Imported Studies
- **ACM Digital Library:** 5
- **Dimensions:** 430
- **El Compendex:** 428
- **IEEE Digital Library:** 433
- **ISI Web of Science:** 387
- **Scopus:** 530