Mining Evidences of Internet of Robotic Things (IoRT) Software from Open Source Projects

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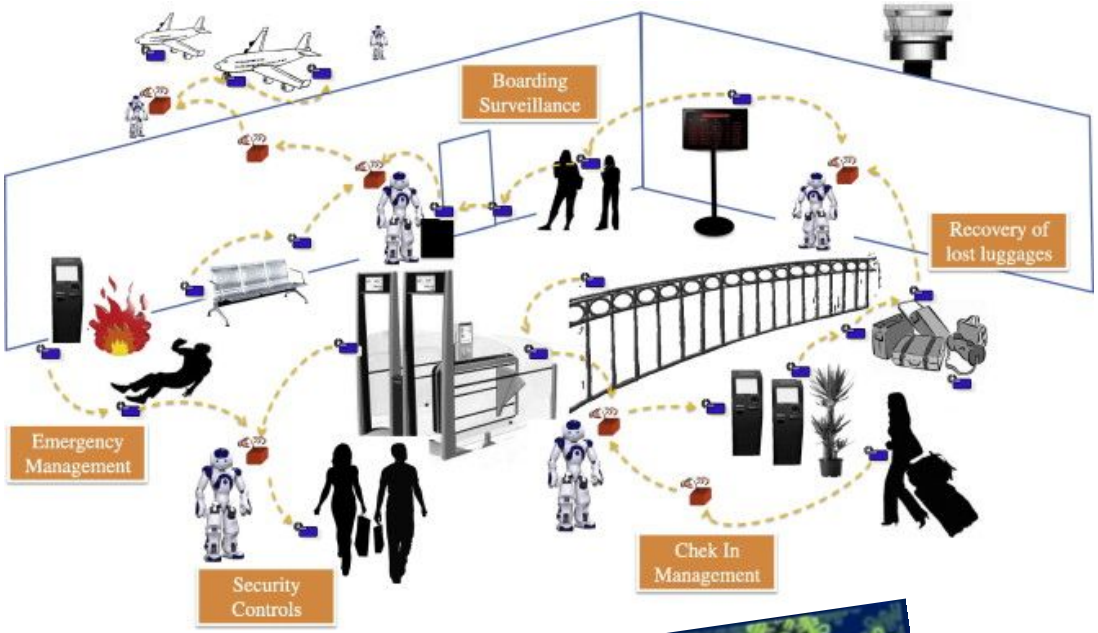

Boarding Surveillance
Recovery of lost luggages
Emergency Management
Security Controls
Chek In Management

Study Goal

- IoRT systems integrate two types of ecosystems that tend to be very complex;
- Lack of documentation of such systems may be catastrophic;
    - People rely on robots and IoT for critical tasks, such as security, autonomous cars, etc.
- The state-of-the-practice has a lot to say;
- This study aims at taking the first step on studying the state-of-the-practice of IoRT software, to be the base of deeper studies.

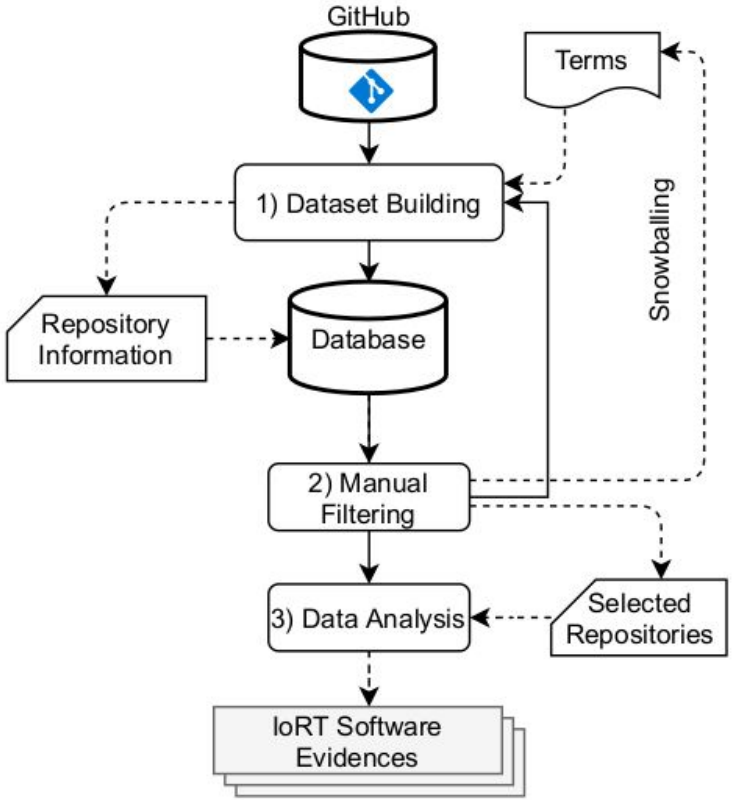
Research Questions

RQ1: How has been the interest and the activity on IoRT systems over time?

RQ2: What are the relevant characteristics of IoRT system repositories?

RQ3: What is the software architectural evidence of IoRT systems?

Methodology

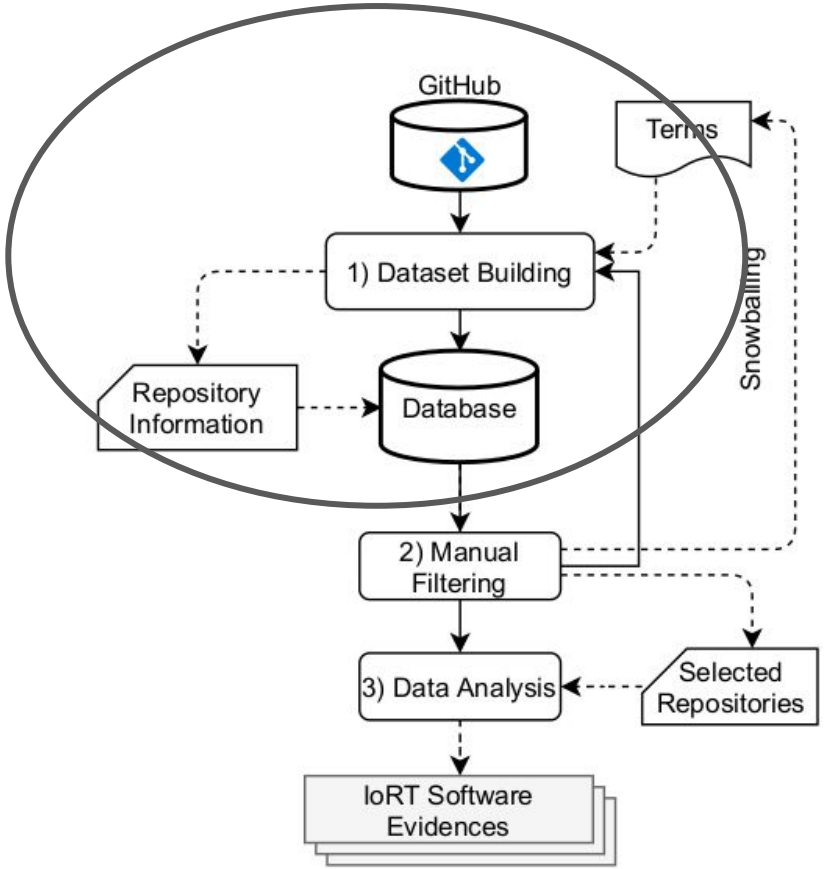


Replication package:

https://github.com/IntelAgir-Research-Group/sbcars2021-replication-package-mining-iot

Methodology

Phase 1



Replication package:

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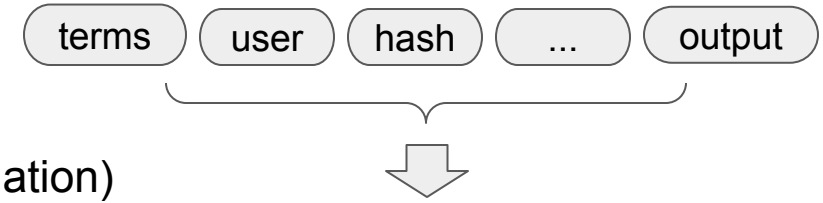
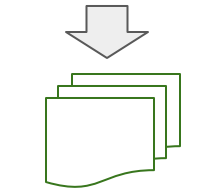
Methodology

Phase 1: Dataset Building



GitHub REST API (shell script automation)

```
curl -u $user:$hash "https://api.github.com/search/repositories?q=$terms+in:$where+created:$date&per_page=100&page=$ii"
    -o $dir"/"$file"-"$i".json"
```

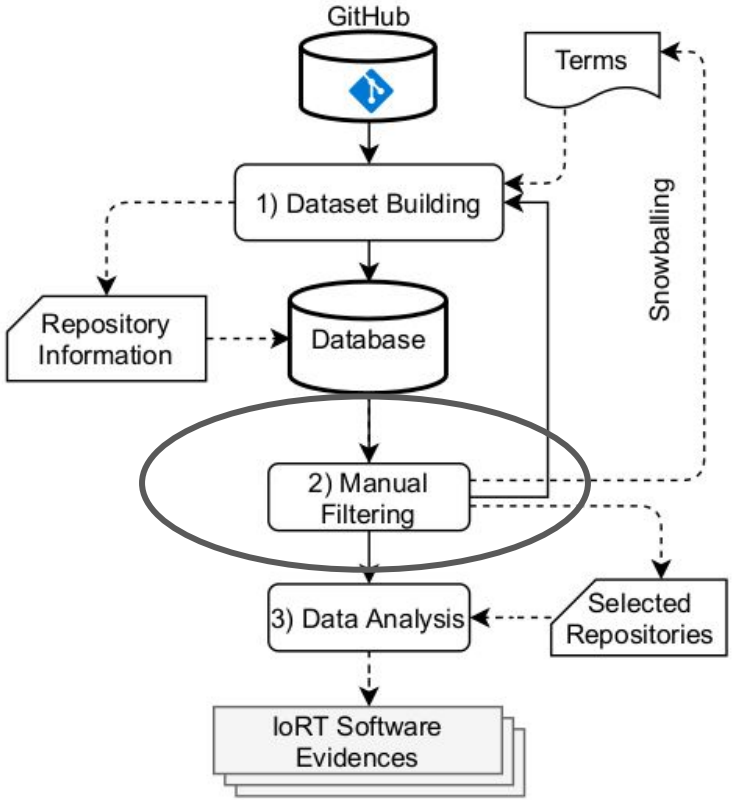


JSON Files

MongoDB would be the “right” storage, but the students were used to SQLite.

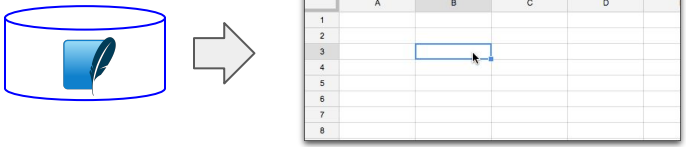
Methodology

Phase 2



Methodology

Phase 2: Manual Filtering

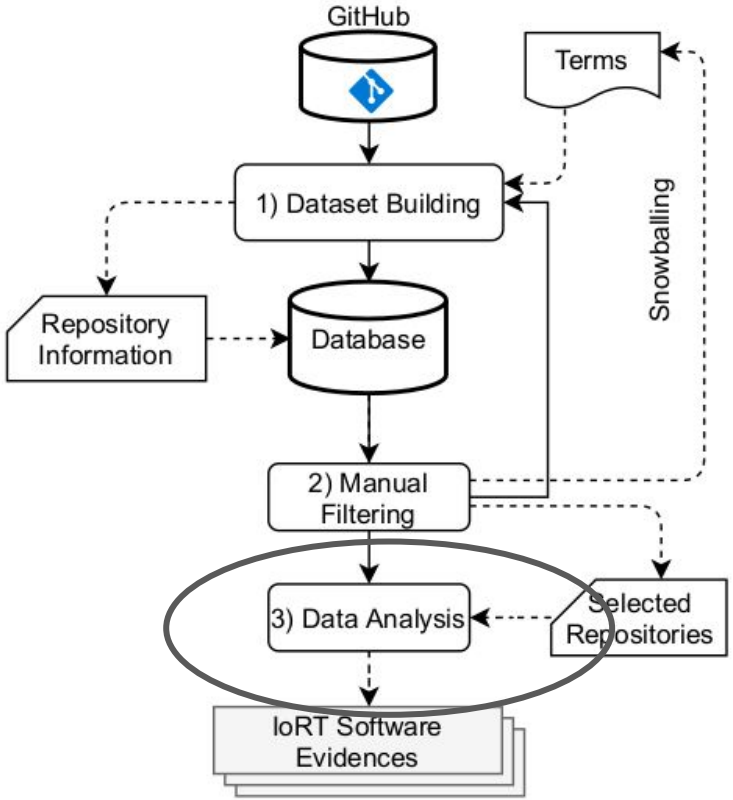


1. Extract description snippets (-25 words [term] +25 words);
2. 2 researchers: decide whether the repositories are about IoRT or not;
   - NO
     - They are discarded.
   - YES
     - Included in the quantitative data.
3. The ones that meet the selection criteria are included in the qualitative data:
   - > 100 words in the description AND
     - > 100 commits (software that has some maturity) OR
     - > 5 contributors (collaborative software dev) OR
     - > 100 stars
   - AND have been updated in the last 2 years (active).

	Min.	Max.	Median	Mean	SD
# commits	1	7599	17.5	154.74	620.27
# contributors	1	378	1	7.45	30.32
# watchers	0	150 550	0	479.10	6023.65
# stars	0	12 200	2	139.55	963.22
# words (README)	1	8325	346	950.24	1481.38

Methodology

Phase 3



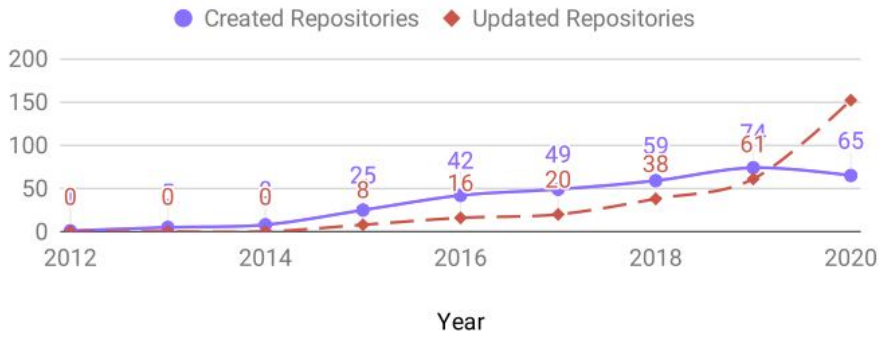
Methodology

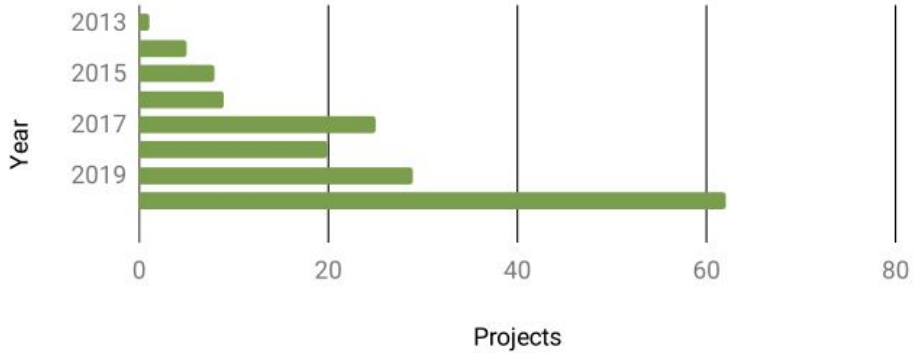
Phase 3: Data Analysis

1. Thematic analysis by 2 of the researchers (Kappa's > 80%);
   a. ***Data familiarization*** (previous phases);
   b. ***Code preset families/categories***: project nature, project domain, IoT capability, robot capability, other relevant.
   c. ***Define themes;***
   d. ***Refine themes***;
   e. ***Document themes.***

Main Results

RQ1: How has been the interest and the activity on IoRT systems over time?





Main Results

RQ2: What are the relevant characteristics of IoRT system repositories?

Project Nature	Projects
Base	P2, P3, P4, P9, P10, P15, P20, P26, P29, P30, P31, P32
Programming Artifact	P5, P8, P10, P11, P12, P 13, P14, P24, P25, P26, P28, P34
Artificial Intelligence	P1, P2, P7, P17, P23
Sensing Data	P7, P18, P22, P23
User Interface	P2, P19
Communication	P21, P27, P33
Device Prototype	P6, P35
Security	P16, P31
Data Analysis	P17

Project Domain	Projects
General	P1, P5, P9, P10, P11, P12, P13, P14, P15, P21, P24, P25, P26, P27, P28, P32, P33, P34
Social robots	P1, P7, P19, P20, P35
Autonomous navigation	P6, P8, P16, P18, P22
Smart home	P3, P19, P23, P31
Smart industy	P17, P29, P30
Education	P30, P35

IoT Capability	Projects
General	P12, P3, P4, P5, P9, P10, P12, P13, P14, P15, P20, P21,P25, P26, P27, P28, P29, P32, P33, P34, P35
Sensor	P1, P6, P7, P8, P17, P18, P22, P23, P24, P31
Actuator	P11, P16, P19, P30

Robot Capability	Projects
General	P2, P3, P5, P9, P10, P11, P12, P13, P14, P15, P19, P20, P21, P25, P26, P27, P28, P29, P31, P32, P33, P34, P35
Navigation	P4, P6, P8, P16, P18, P22, P23
Vision	P1, P4, P7, P8, P24
Control	P4, P6, P16, P30
Base	P17, P19

Main Results

RQ3: What is the software architectural evidence of IoRT systems?

1. *Programing languages:* python, Java, JavaScript...
2. *Software platforms:* TensorFlow, OpenCV, Apache Kafka, Node.js...
3. *Protocols:* MQTT, COAP, AMQP...
4. *Computing infrastructure:* Cloud, AWS IoT, Azure IoT, Docker...
5. *Libraries:* PyTorch, NVidia JetPack, TensorSort...
6. *Middlewares:* ROS, RIOT...
7. *Frameworks:* Robot4J, Gradle, SLAM...
8. *Databases:* Blockchain, KFSQL...

Conclusion and Future Work

- More than a half of the studied projects are still active;
  - Some of them date from ~8 years ago.
- Some projects are very active:
  - Thousands of commits and watchers/starts.
- The evidence from this work will trigger further research:
  - Empirically study the impact of architectural/technical debt on the energy consumption of IoRT software.

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