

# Technical Report: A Systematic Mapping Study of Machine Learning for Software Traceability

## 1. Extracted Data

### 1.1 Extracted Data for RQ1

| Index      | Title   | Author  | Subject    | Year | Venue   | Publication type |
|------------|---|---|------------|------|---|------------------|
| S1<br>[19] | An extended knowledge representation learning approach for context-based traceability link recovery               | Guoshuai Zhao<br>Tong Li<br>Zhen Yang                                     | Researcher | 2020 | International Conference on Software Engineering and Knowledge Engineering (SEKE)   | Conference       |
| S2<br>[18] | An Improved Approach to Traceability Recovery Based on Word Embeddings  | Teng Zhao<br>Qinghua Cao<br>Qing Sun                                      | Student    | 2017 | Asia-Pacific Software Engineering Conference (APSEC)                                | Conference       |
| S3<br>[42] | An information theoretic approach for extracting and tracing non-functional requirements                          | Anas Mahmoud  | Researcher | 2015 | International Requirements Engineering Conference (RE Conference)                   | Conference       |
| S4<br>[48] | Application of reinforcement learning to requirements engineering requirements tracing                            | Hakim Sultanov<br>Jane Huffman Hayes                                      | Researcher | 2013 | International Requirements Engineering Conference (RE Conference)                   | Conference       |
| S5<br>[30] | ATLaS: A Framework for Traceability Links Recovery Combining Information Retrieval and Semi-Supervised Techniques | Emma Effa Bella<br>Stephen Creff<br>Marie-Pierre Gervais<br>Reda Bendraou | Student    | 2019 | The Enterprise Computing Conference (EDOC)  | Conference       |
| S6<br>[44] | Traceability recovery between bug reports and test cases-a Mozilla Firefox case study                             | Guilherme Gadelha<br>Franklin Ramalho<br>Tiago Massoni                    | Researcher | 2021 | Automated Software Engineering (ASE)  | Journal          |
| S7<br>[45] | Automatic traceability link recovery via active learning  | Tianbao Du<br>Guohua Shen<br>Zhiqiu Huang<br>Yaoshen Yu<br>Dexiang Wu     | Student    | 2020 | Frontiers of Information Technology & Electronic Engineering (FRONT INFORM TECH EL) | Journal          |
| S8<br>[3]  | Automatic Traceability Maintenance via Machine Learning Classification  | Chris Mills<br>Javier Escobar-Avila<br>Sonia Haiduc                       | Researcher | 2018 | International Conference on Software Maintenance and Evolution (ICSME)              | Conference       |
| S9<br>[20] | Automating traceability link recovery through classification  | Chris Mills   | Researcher | 2017 | European Software Engineering   | Conference       |

|                           |  |  |              |      |  |            |
|---------------------------|--|--|--------------|------|--|------------|
|                           |  |  |              |      | Conference (ESEC)  |            |
| <b>S10</b><br><b>[46]</b> | Clustering for Traceability Managing in System Specifications  | Manel Mezghani<br>Juyeon Kang<br>Eun-Bee Kang<br>Florence Sedes  | Researcher   | 2019 | International Requirements Engineering Conference (RE Conference)              | Conference |
| <b>S11</b><br><b>[2]</b>  | Combining Machine Learning and Logical Reasoning to Improve Requirements Traceability Recovery   | Tong Li<br>Shiheng Wang<br>David Lillis<br>Zhen Yang   | Researcher   | 2020 | Applied Sciences (APPS)  | Journal    |
| <b>S12</b><br><b>[43]</b> | Detecting, classifying, and tracing non-functional software requirements   | Anas Mahmoud<br>Grant Williams   | Researcher   | 2016 | Requirements Engineering (RE)  | Journal    |
| <b>S13</b><br><b>[31]</b> | Enhancing Automated Requirements Traceability by Resolving Polysemy  | Wentao Wang<br>Nan Niu<br>Hui Liu<br>Zhendong Niu  | Researcher   | 2018 | International Requirements Engineering Conference (RE Conference)              | Conference |
| <b>S14</b><br><b>[22]</b> | A Machine Learning Approach for Determining the Validity of Traceability Links   | Chris Mills<br>Sonia Haiduc  | Researcher   | 2017 | International Conference on Software Engineering (ICSE)                        | Conference |
| <b>S15</b><br><b>[32]</b> | Enhancing Unsupervised Requirements Traceability with Sequential Semantics   | Lei Chen<br>Dandan Wang<br>Junjie Wang<br>Qing Wang  | Researcher   | 2019 | Asia-Pacific Software Engineering Conference (APSEC)                           | Conference |
| <b>S16</b><br><b>[27]</b> | Estimating the number of remaining links in traceability recovery  | Davide Falessi<br>Massimiliano Di Penta<br>Gerardo Canfora<br>Giovanni Cantone   | Researcher   | 2017 | Empirical Software Engineering (ESE)   | Journal    |
| <b>S17</b><br><b>[35]</b> | Evaluation of Textual Similarity Techniques in Code Level Traceability   | Viktor Csuvik<br>Andras Kicsi<br>Laszlo Vidacs   | Student      | 2019 | International Conference on Computational Science and Its Applications (ICCSA) | Conference |
| <b>S18</b><br><b>[47]</b> | Improving the effectiveness of traceability link recovery using hierarchical bayesian networks   | Kevin Moran<br>David N. Palacio<br>Carlos Bernal-Cardenas<br>Daniel McCrystal<br>Denys Poshyvanyk<br>Chris Shenefiel<br>Jeff Johnson | Practitioner | 2020 | International Conference on Software Engineering (ICSE)                        | Conference |
| <b>S19</b><br><b>[41]</b> | Traceability Link Recovery between Requirements and Models using an Evolutionary Algorithm Guided by a Learning to Rank Algorithm: Train control and management case | Ana C. Marcen<br>Raul Lapena<br>Oscar Pastor<br>Carlos Cetina  | Researcher   | 2020 | Journal of Systems and Software (JSS)  | Journal    |
| <b>S20</b><br><b>[33]</b> | Information retrieval versus deep learning approaches for generating traceability links in bilingual projects  | Jinfeng Lin<br>Yalin Liu<br>Jane Cleland-Huang   | Researcher   | 2022 | Empirical Software Engineering (ESE)   | Journal    |

|                           |  |  |              |      |  |                     |
|---------------------------|--|--|--------------|------|--|---------------------|
| <b>S21</b><br><b>[23]</b> | Issue Link Label Recovery and Prediction for Open Source Software                                    | Alexander Nicholson<br>Jin L.C. Guo  | Student      | 2021 | International Requirements Engineering Conference (RE Conference)                  | Conference Workshop |
| <b>S22</b><br><b>[36]</b> | Large Scale Evaluation of Natural Language Processing Based Test-to-Code Traceability Approaches     | Andras Kicsi<br>Viktor Csuvik<br>Laszlo Vidacs   | Researcher   | 2021 | IEEE Access (IEEE ACCESS)  | Journal             |
| <b>S23</b><br><b>[24]</b> | Leveraging Historical Associations between Requirements and Source Code to Identify Impacted Classes | Davide Falessi<br>Justin Roll<br>Jin L.C. Guo<br>Jane Cleland-Huang  | Researcher   | 2020 | IEEE Transactions on Software Engineering (IEEE T SOFTWARE ENG)                    | Journal             |
| <b>S24</b><br><b>[25]</b> | On the effect of incompleteness to check requirement-to-method traces                                | Mouna Hammoudi<br>Christoph Mayr-Dorn<br>Atif Mashkoor<br>Alexander Egyed  | Researcher   | 2021 | ACM Symposium On Applied Computing (SAC)   | Conference          |
| <b>S25</b><br><b>[37]</b> | DeepLink_A Code Knowledge Graph Based Deep Learning Approach for Issue-Commit Link Recovery          | Rui Xie<br>Long Chen<br>Wei Ye<br>Zhiyu Li<br>Tianxiang Hu<br>Dongdong Du<br>Shikun Zhang                              | Researcher   | 2019 | International Conference on Software Analysis, Evolution and Reengineering (SANER) | Conference          |
| <b>S26</b><br><b>[21]</b> | Tracing with Less Data: Active Learning for Classification-Based Traceability Link Recovery          | Chris Mills<br>Javier Escobar-Avila<br>Aditya Bhattacharya<br>Grigoriy Kondyukov<br>Shayok Chakraborty<br>Sonia Haiduc | Researcher   | 2019 | International Conference on Software Maintenance and Evolution (ICSME)             | Conference          |
| <b>S27</b><br><b>[4]</b>  | Semantically Enhanced Software Traceability Using Deep Learning Techniques                           | Jin L.C. Guo<br>Jinghui Cheng<br>Jane Cleland-Huang  | Student      | 2017 | International Conference on Software Engineering (ICSE)                            | Conference          |
| <b>S28</b><br><b>[28]</b> | Semi-Automated Feature Traceability with Embedded Annotations  | Hadil Abukwaik<br>Andreas Burger<br>Berima Kweku Andam<br>Thorsten Berger  | Researcher   | 2018 | International Conference on Software Maintenance and Evolution (ICSME)             | Conference          |
| <b>S29</b><br><b>[38]</b> | Source Code Level Word Embeddings in Aiding Semantic Test-to-Code Traceability                       | Viktor Csuvik<br>Andras Kicsi<br>Laszlo Vidacs   | Student      | 2019 | ICSE Workshop on Software and Systems Traceability (SST)                           | Conference Workshop |
| <b>S30</b><br><b>[29]</b> | Tackling the term-mismatch problem in automated trace retrieval                                      | Jin L.C. Guo<br>Marek Gibiec<br>Jane Cleland-Huang   | Student      | 2017 | Empirical Software Engineering (ESE)   | Journal             |
| <b>S31</b><br><b>[40]</b> | TCTracer: Establishing test-to-code traceability links using dynamic and static techniques           | Robert White<br>Jens Krinke  | Practitioner | 2022 | Empirical Software Engineering (ESE)   | Journal             |
| <b>S32</b>                | Toward accurate link between code and software   | Yingkui Cao  | Researcher   | 2018 | Science China  | Journal             |

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|-------------|--|--|------------|------|---|---------------------|
| [34]        | documentation  | Yanzhen Zou<br>Yuxiang Luo<br>Bing Xie<br>Junfeng Zhao                               |            |      | Information Sciences (SCIS)   |                     |
| S33<br>[49] | Towards feature-aware retrieval of refinement traces                                 | Patrick Rempel<br>Patrick Mader<br>Tobias Kuschke                                    | Student    | 2013 | ICSE Workshop on Traceability in Emerging Forms of Software Engineering (TEFSE) | Conference Workshop |
| S34<br>[6]  | Traceability Transformed_Generating more Accurate Links with Pre-Trained BERT Models | Jinfeng Lin<br>Yalin Liu<br>Qingkai Zeng<br>Meng Jiang<br>Jane Cleland-Huang         | Researcher | 2021 | International Conference on Software Engineering (ICSE)                         | Conference          |
| S35<br>[17] | Towards the automatic classification of traceability links                           | Chris Mills  | Researcher | 2017 | International Conference on Automated Software Engineering (ASE Conference)     | Conference          |
| S36<br>[39] | Tracing Requirements as a Problem of Machine Learning                                | Zeheng Li<br>LiGuo Huang   | Student    | 2018 | International Journal of Software Engineering & Applications (IJSEA)            | Journal             |
| S37<br>[26] | Traceability in the wild: automatically augmenting incomplete trace links            | Michael Rath<br>Jacob Rendall<br>Jin L.C. Guo<br>Jane Cleland-Huang<br>Patrick Mader | Researcher | 2018 | International Conference on Software Engineering (ICSE)                         | Conference          |

## 1.2 Extracted Data for RQ1

| Index | Title   | ML Models   | Stage  |
|-------|---|---|--|
| S1    | An extended knowledge representation learning approach for context-based traceability link recovery               | Decision Tree (DT)<br>GBDT<br>Naive Bayes (NB)<br>SVM | link generation stage                        |
| S2    | An Improved Approach to Traceability Recovery Based on Word Embeddings  | Word2vec<br>Ranking SVM                               | preprocessing stage<br>link generation stage |
| S3    | An information theoretic approach for extracting and tracing non-functional requirements                          | Hierarchical Agglomerative Clustering (HAC)           | preprocessing stage                          |
| S4    | Application of reinforcement learning to requirements engineering requirements tracing                            | Reinforcement Learning                                | link generation stage                        |
| S5    | ATLaS: A Framework for Traceability Links Recovery Combining Information Retrieval and Semi-Supervised Techniques | Word2vec<br>GloVe<br>Label spreading                  | preprocessing stage<br>link generation stage |
| S6    | Traceability recovery between bug reports and test cases-a Mozilla Firefox case study                             | GloVe   | preprocessing stage                          |

|            |  |  |  |
|------------|--|--|--|
| <b>S7</b>  | Automatic traceability link recovery via active learning   | Active Learning  | link generation stage                        |
| <b>S8</b>  | Automatic Traceability Maintenance via Machine Learning Classification   | K nearest neighbors (KNN)<br>Naive Bayes (NB)<br>Logistic Regression (LR)<br>SVM<br>Random Forest (RF) | link generation stage                        |
| <b>S9</b>  | Automating traceability link recovery through classification   | Decision Tree (DT)<br>Random Forest (RF)<br>K nearest neighbors (KNN)<br>Naive Bayes (NB)              | link generation stage                        |
| <b>S10</b> | Clustering for Traceability Managing in System Specifications  | K-means  | link generation stage                        |
| <b>S11</b> | Combining Machine Learning and Logical Reasoning to Improve Requirements Traceability Recovery   | Doc2vec<br>Decision Tree (DT)<br>K nearest neighbors (KNN)<br>Random Forest (RF)<br>GBDT               | preprocessing stage<br>link generation stage |
| <b>S12</b> | Detecting, classifying, and tracing non-functional software requirements   | Hierarchical Agglomerative Clustering (HAC)<br>K-medoids   | preprocessing stage                          |
| <b>S13</b> | Enhancing Automated Requirements Traceability by Resolving Polysemy  | MLP<br>Word2vec  | preprocessing stage                          |
| <b>S14</b> | A Machine Learning Approach for Determining the Validity of Traceability Links   | Random Forest (RF)   | link generation stage                        |
| <b>S15</b> | Enhancing Unsupervised Requirements Traceability with Sequential Semantics   | Word2vec<br>Doc2vec  | preprocessing stage                          |
| <b>S16</b> | Estimating the number of remaining links in traceability recovery  | Decision Tree (DT)<br>Bagging<br>K nearest neighbors (KNN)<br>Logit Boost<br>Naive Bayes (NB)          | link generation stage                        |
| <b>S17</b> | Evaluation of Textual Similarity Techniques in Code Level Traceability   | Doc2vec  | preprocessing stage                          |
| <b>S18</b> | Improving the effectiveness of traceability link recovery using hierarchical bayesian networks   | Hierarchical Bayesian Network (HBN)  | link generation stage                        |
| <b>S19</b> | Traceability Link Recovery between Requirements and Models using an Evolutionary Algorithm Guided by a Learning to Rank Algorithm: Train control and management case | MLP<br>RNN<br>RankBoost  | link generation stage                        |
| <b>S20</b> | Information retrieval versus deep learning approaches for generating traceability links in bilingual projects  | Word2vec<br>FastText<br>BERT   | preprocessing stage                          |
| <b>S21</b> | Issue Link Label Recovery and Prediction for Open Source Software  | FastText<br>Logistic Regression (LR)<br>Random Forest (RF)   | preprocessing stage<br>link generation stage |

|     |  |   |  |
|-----|--|---|--|
|     |  | Neural Network (NN)   |  |
| S22 | Large Scale Evaluation of Natural Language Processing Based Test-to-Code Traceability Approaches     | Doc2vec   | preprocessing stage                          |
| S23 | Leveraging Historical Associations between Requirements and Source Code to Identify Impacted Classes | Decision Tree (DT)<br>Random Forest (RF)<br>Logistic Regression (LR)<br>Naive Bayes (NB)<br>Bagging | link generation stage                        |
| S24 | On the effect of incompleteness to check requirement-to-method traces                                | Decision Tree (DT)<br>Random Forest (RF)<br>Naive Bayes (NB)<br>K nearest neighbors (KNN)           | link generation stage                        |
| S25 | DeepLink_A Code Knowledge Graph Based Deep Learning Approach for Issue-Commit Link Recovery          | Word2vec<br>GRU<br>RNN<br>MLP<br>SVM  | preprocessing stage<br>link generation stage |
| S26 | Tracing with Less Data: Active Learning for Classification-Based Traceability Link Recovery          | Active Learning<br>Random Forest (RF)   | link generation stage                        |
| S27 | Semantically Enhanced Software Traceability Using Deep Learning Techniques                           | Word2vec<br>RNN<br>LSTM<br>Bi-LSTM<br>GRU<br>Bi-GRU   | preprocessing stage                          |
| S28 | Semi-Automated Feature Traceability with Embedded Annotations  | SVM<br>K nearest neighbors (KNN)<br>Decision Tree (DT)  | link generation stage                        |
| S29 | Source Code Level Word Embeddings in Aiding Semantic Test-to-Code Traceability                       | Doc2vec   | preprocessing stage                          |
| S30 | Tackling the term-mismatch problem in automated trace retrieval                                      | Decision Tree (DT)<br>Naive Bayes (NB)  | link generation stage                        |
| S31 | TCTracer: Establishing test-to-code traceability links using dynamic and static techniques           | MLP   | link generation stage                        |
| S32 | Toward accurate link between code and software documentation   | Word2vec<br>GBDT  | preprocessing stage<br>link generation stage |
| S33 | Towards feature-aware retrieval of refinement traces   | Spectral Clustering   | link refinement stage                        |
| S34 | Traceability Transformed_Generating more Accurate Links with Pre-Trained BERT Models                 | BERT<br>LSTM<br>Bi-GRU  | link generation stage                        |
| S35 | Towards the automatic classification of traceability links   | Decision Tree (DT)<br>Random Forest (RF)<br>K nearest neighbors (KNN)<br>Naive Bayes (NB)           | link generation stage                        |

|            |   |  |  |
|------------|---|--|--|
| <b>S36</b> | Tracing Requirements as a Problem of Machine Learning                     | SVM<br>Single link clustering                                | link generation stage<br>preprocessing stage |
| <b>S37</b> | Traceability in the wild: automatically augmenting incomplete trace links | Naive Bayes (NB)<br>Decision Tree (DT)<br>Random Forest (RF) | link generation stage                        |

### 1.3 Extracted Data for RQ2

| Index              | Source Artifact (number)  | Target Artifact (number)   | Datasets (true link number)                             | Evidence Level  |
|--------------------|---|--|---|---|
| <b>S1</b><br>[19]  | Use Case  | Code   | eTour   | Level 1: Evaluation conducted in academic context (0.6) |
| <b>S2</b><br>[18]  | High-level requirement<br>Use case<br>Use case<br>Use case  | Low-level requirement<br>Code<br>Interaction Diagrams<br>Test Case                 | CM-1-NASA<br>GANNT<br>eTOUR<br>iTrust<br>EasyClinic     | Level 1: Evaluation conducted in academic context (0.6) |
| <b>S3</b><br>[42]  | Requirement   | Code   | SmartTrip *<br>SafeDrink *<br>BlueWallet *              | Level 2: Evaluation conducted in industry context (1.0) |
| <b>S4</b><br>[48]  | Requirement<br>Requirement  | Use case<br>Design   | Pine<br>CM-1-SUB  | Level 1: Evaluation conducted in academic context (0.6) |
| <b>S5</b><br>[30]  | High-level requirements   | Design   | ARC-IT  | Level 2: Evaluation conducted in industry context (1.0) |
| <b>S6</b><br>[44]  | Bug Report  | Test Case  | Mozilla Firefox   | Level 1: Evaluation conducted in academic context (0.6) |
| <b>S7</b><br>[45]  | High-level requirement<br>Use Case<br>Test Case<br>Test Case<br>Interaction Diagram   | Low-level requirement<br>Code<br>Use Case<br>Code<br>Test Case                     | eAnci<br>SMOS<br>MODIS<br>EasyClinic<br>eTour           | Level 1: Evaluation conducted in academic context (0.6) |
| <b>S8</b><br>[3]   | High-level requirement<br>Use Case<br>Test Case<br>Test Case<br>Interaction Diagram<br>Interaction Diagram<br>Interaction Diagram | Low-level requirement<br>Code<br>Use Case<br>Code<br>Test Case<br>Code<br>Use Case | eAnci<br>SMOS<br>MODIS<br>EasyClinic<br>eTour<br>iTrust | Level 1: Evaluation conducted in academic context (0.6) |
| <b>S9</b><br>[20]  | High-level requirement<br>Use Case<br>Test Case<br>Test Case<br>Interaction Diagram<br>Interaction Diagram<br>Interaction Diagram | Low-level requirement<br>Code<br>Use Case<br>Code<br>Test Case<br>Code<br>Use Case | eAnci<br>SMOS<br>EasyClinic<br>eTour<br>iTrust<br>CM-1  | Level 1: Evaluation conducted in academic context (0.6) |
| <b>S10</b><br>[46] | Requirement   | Requirement  | Dataset1 *<br>Dataset2 *                                | Level 1: Evaluation conducted in academic context (0.6) |
| <b>S11</b><br>[2]  | Use Case  | Code   | eTour<br>SMOS   | Level 1: Evaluation conducted in academic context (0.6) |

|                           |   |   |  |  |
|---------------------------|---|---|--|--|
|                           |   |   | Albergate<br>eAnci   |  |
| <b>S12</b><br><b>[43]</b> | Requirement   | Code  | SmartTrip ★<br>SafeDrink ★<br>BlueWallet ★                                     | Level 2: Evaluation conducted in<br>industry context (1.0) |
| <b>S13</b><br><b>[31]</b> | Requirement<br>Requirement  | Requirement<br>Design   | AIRFLOW<br>ANY23<br>DASHBUILDER<br>DROOLS<br>IMMUTANT<br>JBTM<br>MODIS<br>CM-1 | Level 1: Evaluation conducted in<br>academic context (0.6) |
| <b>S14</b><br><b>[22]</b> | Use Case  | Code  | eAnci<br>eTour<br>SMOS   | Level 1: Evaluation conducted in<br>academic context (0.6) |
| <b>S15</b><br><b>[32]</b> | Requirement<br>Use Case<br>Use Case<br>Use Case   | Requirement<br>Code<br>Test Case<br>Interaction Diagram   | GANNT<br>CM-1-NASA<br>eTour<br>iTrust<br>EasyClinic                            | Level 1: Evaluation conducted in<br>academic context (0.6) |
| <b>S16</b><br><b>[27]</b> | Requirement<br>Use Case<br>Use Case<br>Use Case<br>Use Case<br>Test Case<br>Test Case<br>Interaction Diagram<br>Interaction Diagram<br>Interaction Diagram<br>Interaction Diagram<br>Code<br>Code | Requirement<br>Code<br>Use Case<br>Test Case<br>Interaction Diagram<br>Test Case<br>Code<br>Interaction Diagram<br>Code<br>Test Case<br>Use Case<br>Code<br>Code<br>Test Case | Selex SI<br>eTour<br>EasyClinic  | Level 2: Evaluation conducted in<br>industry context (1.0) |
| <b>S17</b><br><b>[35]</b> | Test Case   | Code  | Commons Lang<br>Commons Math<br>JfreeChart<br>MONDRIAN                         | Level 1: Evaluation conducted in<br>academic context (0.6) |
| <b>S18</b><br><b>[47]</b> | Requirement<br>Requirement<br>Use Case  | Code<br>Test Case<br>Code   | Albergate<br>EBT<br>LibEST<br>eTour<br>SMOS<br>iTrust                          | Level 2: Evaluation conducted in<br>industry context (1.0) |
| <b>S19</b><br><b>[41]</b> | Requirement   | Model   | CAF  | Level 2: Evaluation conducted in<br>industry context (1.0) |
| <b>S20</b><br><b>[33]</b> | Commit  | Issue   | Arthas<br>bk-cmdb<br>Canal   | Level 1: Evaluation conducted in<br>academic context (0.6) |



|             |   |  |   |   |
|-------------|---|--|---|---|
|             |   |  | Druid<br>Emmagee<br>Nacos<br>NCNN<br>Pegasus<br>QMUI Android<br>QMUI IOS<br>Rax<br>San<br>Weui<br>xLua<br>Konlpy<br>Cica<br>Aws-berline |   |
| S21<br>[23] | Issue   | Issue  | AMBARI<br>FLEX<br>HIVE  | Level 1: Evaluation conducted in academic context (0.6) |
| S22<br>[36] | Test Case   | Code   | ArgoUML<br>Commons Lang<br>Commons Math<br>Gson<br>JfreeChart<br>Joda-Time<br>MONDRIAN<br>PMD   | Level 1: Evaluation conducted in academic context (0.6) |
| S23<br>[24] | Requirement   | Code   | Accumulo<br>Ignite<br>Isis<br>Tika  | Level 1: Evaluation conducted in academic context (0.6) |
| S24<br>[25] | Requirement   | Code   | Chess<br>Gantt<br>iTrust<br>JHotDraw  | Level 2: Evaluation conducted in industry context (1.0) |
| S25<br>[37] | commit  | issue  | ZOOKEEPER<br>MAHOUT<br>CHUKWA<br>AVRO<br>LANG<br>TEZ  | Level 2: Evaluation conducted in academic context (0.6) |
| S26<br>[21] | High-level requirement<br>Use Case<br>Test Case<br>Test Case<br>Interaction Diagram<br>Interaction Diagram<br>Interaction Diagram | Low-level requirement<br>Code<br>Use Case<br>Code<br>Test Case<br>Code<br>Use Case | eAnci<br>SMOS<br>MODIS<br>EasyClinic<br>eTour<br>iTrust   | Level 1: Evaluation conducted in academic context (0.6) |
| S27<br>[4]  | Requirement   | Design   | PTC   | Level 2: Evaluation conducted in industry context (1.0) |
| S28         | Code  | Code   | Clafer Tools  | Level 1: Evaluation conducted in                        |

|             |  |   |   |  |
|-------------|--|---|---|--|
| [28]        |  |   |   | academic context (0.6)                                     |
| S29<br>[38] | Test Case  | Code  | Commons Lang<br>Commons Math<br>JfreeChart<br>MONDRIAN  | Level 1: Evaluation conducted in<br>academic context (0.6) |
| S30<br>[29] | Regulatory code  | Requirement   | Care2x<br>CCHIT<br>ClearHealth<br>Physician<br>iTrust<br>Trial Implementations<br>PatientOS<br>PracticeOne<br>Lauesen<br>WorldVistA | Level 1: Evaluation conducted in<br>academic context (0.6) |
| S31<br>[40] | Test Case  | Code  | Apache Ant<br>Commons IO<br>Commons Lang<br>JfreeChart<br>Gson  | Level 1: Evaluation conducted in<br>academic context (0.6) |
| S32<br>[34] | Code   | Software documentation  | Lucene  | Level 1: Evaluation conducted in<br>academic context (0.6) |
| S33<br>[49] | Requirement<br>Use Case<br>Feature   | Use Case<br>Test Case<br>Use Case                                       | CM-1<br>EasyClinic<br>Waterloo  | Level 2: Evaluation conducted in<br>industry context (1.0) |
| S34<br>[6]  | Commit   | Issue   | CodeSearchNet<br>Pgcli<br>Flask<br>Keras  | Level 1: Evaluation conducted in<br>academic context (0.6) |
| S35<br>[17] | Requirement<br>Use Case<br>Test Case<br>Interaction Diagram<br>Interaction Diagram<br>Test Case<br>Interaction Diagram | Requiremen<br>Code<br>Code<br>Test Case<br>Use Case<br>Use Case<br>Code | CM-1<br>eAnci<br>eTour<br>SMOS<br>iTrust<br>EasyClinic  | Level 1: Evaluation conducted in<br>academic context (0.6) |
| S36<br>[39] | Requirement  | Use case  | Pine  | Level 1: Evaluation conducted in<br>academic context (0.6) |
| S37<br>[26] | Commit   | Issue   | Maven<br>Derby<br>Infinispan<br>Groovy<br>Pig<br>Drools   | Level 1: Evaluation conducted in<br>academic context (0.6) |

\* present that author uses a pseudonym of the name of dataset for confidentiality agreements

## 1.4 Extracted Data for RQ3

| Index       | Title   | Measures   | Evidence Level  |
|-------------|---|--|---|
| S1<br>[9]   | An extended knowledge representation learning approach for context-based traceability link recovery               | Precision<br>Recall<br>F-Measure                               | Level 3: Evidence obtained from academic studies (0.6).   |
| S2<br>[8]   | An Improved Approach to Traceability Recovery Based on Word Embeddings  | Precision<br>Recall<br>F-Measure<br>MAP<br>MRR<br>Running Time | Level 3: Evidence obtained from academic studies (0.6).   |
| S3<br>[42]  | An information theoretic approach for extracting and tracing non-functional requirements                          | Precision<br>Recall  | Level 3: Evidence obtained from academic studies (0.6).   |
| S4<br>[48]  | Application of reinforcement learning to requirements engineering requirements tracing                            | Precision<br>Recall<br>F-Measure                               | Level 3: Evidence obtained from academic studies (0.6).   |
| S5<br>[30]  | ATLaS: A Framework for Traceability Links Recovery Combining Information Retrieval and Semi-Supervised Techniques | Precision<br>Recall<br>F-Measure                               | Level 4: Evidence obtained from industrial studies (0.6). |
| S6<br>[44]  | Traceability recovery between bug reports and test cases-a Mozilla Firefox case study                             | Recall<br>Precision<br>F-Measure<br>REI                        | Level 4: Evidence obtained from industrial studies (0.6). |
| S7<br>[45]  | Automatic traceability link recovery via active learning  | Precision<br>Recall<br>F-Measure                               | Level 3: Evidence obtained from academic studies (0.6).   |
| S8<br>[3]   | Automatic Traceability Maintenance via Machine Learning Classification  | Precision<br>Recall<br>F-Measure                               | Level 3: Evidence obtained from academic studies (0.6).   |
| S9<br>[10]  | Automating traceability link recovery through classification  | Recall<br>FPR  | Level 3: Evidence obtained from academic studies (0.6).   |
| S10<br>[46] | Clustering for Traceability Managing in System Specifications   | Precision  | Level 3: Evidence obtained from academic studies (0.6).   |
| S11<br>[2]  | Combining Machine Learning and Logical Reasoning to Improve Requirements Traceability Recovery                    | Precision<br>Recall<br>F-Measure                               | Level 3: Evidence obtained from academic studies (0.6).   |
| S12<br>[43] | Detecting, classifying, and tracing non-functional software requirements  | Precision<br>Recall  | Level 3: Evidence obtained from academic studies (0.6).   |
| S13<br>[31] | Enhancing Automated Requirements Traceability by Resolving Polysemy   | Precision<br>Recall<br>F-Measure                               | Level 3: Evidence obtained from academic studies (0.6).   |
| S14<br>[22] | A Machine Learning Approach for Determining the Validity of Traceability Links                                    | TP<br>FP   | Level 3: Evidence obtained from academic studies (0.6).   |
| S15<br>[32] | Enhancing Unsupervised Requirements Traceability with Sequential Semantics  | Precision<br>Recall<br>F-Measure                               | Level 3: Evidence obtained from academic studies (0.6).   |
| S16<br>[27] | Estimating the number of remaining links in traceability recovery   | MRE<br>MAE   | Level 3: Evidence obtained from academic studies (0.6).   |

|                           |  |  |   |
|---------------------------|--|--|---|
| <b>S17</b><br><b>[35]</b> | Evaluation of Textual Similarity Techniques in Code Level Traceability   | Precision  | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S18</b><br><b>[47]</b> | Improving the effectiveness of traceability link recovery using hierarchical bayesian networks   | Precision<br>Recall<br>Average Precision (AP)                              | Level 4: Evidence obtained from industrial studies (0.6). |
| <b>S19</b><br><b>[41]</b> | Traceability Link Recovery between Requirements and Models using an Evolutionary Algorithm Guided by a Learning to Rank Algorithm: Train control and management case | Recall<br>Precision<br>F-Measure<br>Matthews Correlation Coefficient (MCC) | Level 4: Evidence obtained from industrial studies (0.6). |
| <b>S20</b><br><b>[33]</b> | Information retrieval versus deep learning approaches for generating traceability links in bilingual projects  | Average Precision (AP)<br>F-Measure  | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S21</b><br><b>[23]</b> | Issue Link Label Recovery and Prediction for Open Source Software  | F-Measure  | Level 4: Evidence obtained from industrial studies (0.6). |
| <b>S22</b><br><b>[36]</b> | Large Scale Evaluation of Natural Language Processing Based Test-to-Code Traceability Approaches   | Precision  | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S23</b><br><b>[24]</b> | Leveraging Historical Associations between Requirements and Source Code to Identify Impacted Classes   | Precision<br>Recall<br>F-Measure   | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S24</b><br><b>[25]</b> | On the effect of incompleteness to check requirement-to-method traces  | Precision<br>Recall<br>F-Measure   | Level 4: Evidence obtained from industrial studies (0.6). |
| <b>S25</b><br><b>[37]</b> | DeepLink_A Code Knowledge Graph Based Deep Learning Approach for Issue-Commit Link Recovery  | Precision<br>Recall<br>F-Measure   | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S26</b><br><b>[21]</b> | Tracing with Less Data: Active Learning for Classification-Based Traceability Link Recovery  | F-Measure  | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S27</b><br><b>[4]</b>  | Semantically Enhanced Software Traceability Using Deep Learning Techniques   | Precision<br>Recall<br>MAP   | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S28</b><br><b>[28]</b> | Semi-Automated Feature Traceability with Embedded Annotations  | Precision<br>Recall<br>F-Measure   | Level 4: Evidence obtained from industrial studies (0.6). |
| <b>S29</b><br><b>[38]</b> | Source Code Level Word Embeddings in Aiding Semantic Test-to-Code Traceability   | Precision  | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S30</b><br><b>[29]</b> | Tackling the term-mismatch problem in automated trace retrieval  | Precision<br>Recall<br>F-Measure<br>MAP                                    | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S31</b><br><b>[40]</b> | TCTracer: Establishing test-to-code traceability links using dynamic and static techniques   | Precision<br>Recall<br>F-Measure<br>MAP<br>AUC                             | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S32</b><br><b>[34]</b> | Toward accurate link between code and software documentation   | Precision<br>Recall  | Level 3: Evidence obtained from academic studies (0.6).   |

|                           |   |  |   |
|---------------------------|---|--|---|
|                           |   | F-Measure<br>TNR                                     |   |
| <b>S33</b><br><b>[49]</b> | Towards feature-aware retrieval of refinement traces                                    | Precision<br>Recall<br>Average Precision (AP)        | Level 4: Evidence obtained from industrial studies (0.6). |
| <b>S34</b><br><b>[7]</b>  | Traceability Transformed_Generating more Accurate<br>Links with Pre-Trained BERT Models | F-Measure<br>MAP<br>MRR<br>Precision<br>Running Time | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S35</b><br><b>[5]</b>  | Towards the automatic classification of traceability<br>links                           | Recall<br>FPR  | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S36</b><br><b>[39]</b> | Tracing Requirements as a Problem of Machine<br>Learning                                | Recall<br>Precision<br>F-Measure                     | Level 3: Evidence obtained from academic studies (0.6).   |
| <b>S37</b><br><b>[26]</b> | Traceability in the wild: automatically augmenting<br>incomplete trace links            | Precision<br>Recall<br>F-Measure                     | Level 3: Evidence obtained from academic studies (0.6).   |

### 1.5 Extracted Data for RQ4

| Index\ Factors | Method  |                 |                    |             | Data                 |                |         | Experiment                |             |                         |                       |                  | Score |      |     |
|----------------|---------|-----------------|--------------------|-------------|----------------------|----------------|---------|---------------------------|-------------|-------------------------|-----------------------|------------------|-------|------|-----|
|                | Problem | Research method | Research questions | Pseudo code | Dataset partitioning | Dataset source | Results | Hypothesis and Prediction | Source code | Hardware specifications | Software dependencies | Experiment setup | D1    | D2   | D3  |
| S1             | 0       | 1               | 1                  | 0           | 1                    | 1              | 1       | 0                         | 1           | 0                       | 1                     | 1                | 0.5   | 1    | 0.6 |
| S2             | 1       | 1               | 0                  | 0           | 1                    | 1              | 0       | 1                         | 0           | 1                       | 0                     | 1                | 0.5   | 0.66 | 0.6 |
| S3             | 1       | 1               | 1                  | 0           | 0                    | 0              | 0       | 0                         | 0           | 0                       | 0                     | 0                | 0.75  | 0    | 0   |
| S4             | 0       | 1               | 0                  | 1           | 1                    | 0              | 0       | 1                         | 0           | 0                       | 0                     | 1                | 0.5   | 0.33 | 0.4 |
| S5             | 1       | 1               | 1                  | 0           | 1                    | 1              | 0       | 0                         | 0           | 1                       | 1                     | 0                | 0.75  | 0.66 | 0.4 |
| S6             | 1       | 1               | 1                  | 0           | 0                    | 1              | 1       | 0                         | 1           | 1                       | 1                     | 1                | 0.75  | 1    | 0.8 |
| S7             | 0       | 0               | 1                  | 1           | 1                    | 0              | 0       | 1                         | 0           | 0                       | 0                     | 1                | 0.5   | 0.33 | 0.4 |
| S8             | 1       | 1               | 1                  | 0           | 1                    | 1              | 1       | 0                         | 0           | 0                       | 0                     | 1                | 0.75  | 1    | 0.2 |
| S9             | 0       | 0               | 0                  | 0           | 1                    | 0              | 0       | 0                         | 0           | 0                       | 1                     | 1                | 0     | 0.33 | 0.4 |
| S10            | 1       | 0               | 0                  | 0           | 0                    | 0              | 0       | 0                         | 0           | 0                       | 0                     | 1                | 0.25  | 0    | 0.2 |
| S11            | 1       | 1               | 1                  | 0           | 0                    | 0              | 0       | 0                         | 0           | 0                       | 0                     | 1                | 0.75  | 0    | 0.2 |
| S12            | 0       | 1               | 1                  | 0           | 0                    | 0              | 0       | 0                         | 0           | 0                       | 1                     | 1                | 0.5   | 0    | 0.4 |
| S13            | 1       | 1               | 0                  | 0           | 0                    | 0              | 0       | 0                         | 0           | 0                       | 1                     | 1                | 0.5   | 0    | 0.4 |
| S14            | 0       | 0               | 0                  | 0           | 0                    | 0              | 0       | 0                         | 0           | 0                       | 1                     | 0                | 0     | 0    | 0.2 |
| S15            | 1       | 1               | 1                  | 0           | 0                    | 1              | 0       | 0                         | 0           | 0                       | 1                     | 1                | 0.75  | 0.5  | 0.4 |
| S16            | 1       | 0               | 1                  | 1           | 1                    | 1              | 0       | 1                         | 1           | 0                       | 1                     | 1                | 0.75  | 0.66 | 0.8 |
| S17            | 0       | 1               | 1                  | 0           | 0                    | 1              | 0       | 0                         | 0           | 0                       | 1                     | 0                | 0.5   | 0.5  | 0.2 |
| S18            | 1       | 1               | 1                  | 0           | 0                    | 1              | 0       | 0                         | 1           | 0                       | 1                     | 1                | 0.75  | 0.33 | 0.6 |
| S19            | 1       | 1               | 0                  | 0           | 1                    | 1              | 0       | 1                         | 1           | 0                       | 1                     | 0                | 0.5   | 0.66 | 0.6 |
| S20            | 1       | 1               | 1                  | 0           | 1                    | 1              | 0       | 0                         | 1           | 0                       | 1                     | 1                | 0.75  | 0.66 | 0.6 |
| S21            | 1       | 1               | 1                  | 0           | 1                    | 1              | 0       | 0                         | 0           | 0                       | 1                     | 1                | 0.75  | 0.66 | 0.4 |
| S22            | 1       | 1               | 1                  | 0           | 0                    | 0              | 0       | 0                         | 0           | 0                       | 1                     | 1                | 0.75  | 0    | 0.4 |
| S23            | 0       | 1               | 1                  | 0           | 1                    | 0              | 0       | 0                         | 0           | 0                       | 0                     | 1                | 0.5   | 0.33 | 0.2 |

|             |    |    |    |   |    |    |   |   |    |   |    |    |      |      |     |
|-------------|----|----|----|---|----|----|---|---|----|---|----|----|------|------|-----|
| S24         | 1  | 1  | 1  | 0 | 1  | 1  | 0 | 0 | 1  | 0 | 1  | 0  | 0.75 | 0.66 | 0.4 |
| S25         | 1  | 1  | 1  | 0 | 0  | 1  | 0 | 0 | 1  | 0 | 1  | 1  | 0.75 | 0.5  | 0.6 |
| S26         | 1  | 0  | 1  | 0 | 1  | 1  | 1 | 0 | 1  | 0 | 1  | 1  | 0.5  | 1    | 0.6 |
| S27         | 1  | 1  | 1  | 0 | 1  | 0  | 0 | 0 | 1  | 0 | 1  | 1  | 0.75 | 0.33 | 0.6 |
| S28         | 1  | 1  | 1  | 0 | 1  | 0  | 0 | 0 | 0  | 0 | 0  | 0  | 0.75 | 0.33 | 0   |
| S29         | 1  | 1  | 1  | 0 | 0  | 1  | 0 | 0 | 0  | 0 | 1  | 1  | 0.75 | 0.5  | 0.4 |
| S30         | 1  | 1  | 0  | 0 | 1  | 1  | 0 | 1 | 0  | 0 | 0  | 1  | 0.5  | 0.66 | 0.4 |
| S31         | 1  | 1  | 1  | 0 | 1  | 1  | 0 | 0 | 1  | 0 | 1  | 1  | 0.75 | 0.66 | 0.6 |
| S32         | 1  | 1  | 1  | 0 | 1  | 0  | 0 | 0 | 0  | 0 | 0  | 1  | 0.75 | 0.33 | 0.2 |
| S33         | 1  | 1  | 0  | 0 | 0  | 1  | 0 | 1 | 0  | 0 | 0  | 1  | 0.5  | 0.5  | 0.4 |
| S34         | 1  | 1  | 1  | 0 | 1  | 1  | 0 | 0 | 1  | 1 | 1  | 1  | 0.75 | 0.66 | 0.8 |
| S35         | 1  | 0  | 0  | 0 | 0  | 0  | 0 | 0 | 0  | 0 | 1  | 0  | 0.25 | 0    | 0.2 |
| S36         | 1  | 1  | 0  | 0 | 1  | 0  | 0 | 0 | 0  | 0 | 0  | 1  | 0.5  | 0.33 | 0.2 |
| S37         | 1  | 1  | 1  | 0 | 1  | 0  | 0 | 0 | 0  | 0 | 0  | 1  | 0.75 | 0.33 | 0.2 |
| Num of True | 30 | 31 | 26 | 3 | 23 | 21 | 4 | 8 | 13 | 4 | 24 | 29 |      |      |     |

## 1.6 The information of Datasets and the studied papers which used the datasets

| Dataset Name | Source Artifacts (Number) | Target Artifacts (Number) | True link | Scale (Total) | Source Link           | Freq | Primary researches  |
|--------------|---------------------------|---------------------------|-----------|---------------|-----------------------|------|---|
| eTour        | Use Case (58)             | Code (116)                | 336       | (174)         | http://www.coest.org/ | 12   | [S1] [S2] [S7] [S8] [S9]<br>[S11] [S14] [S15]<br>[S16] [S18] [S26]<br>[S35] |
|              | Use Case (58)             | Code (116)                | 308       | (174)         |                       |      |   |
|              | Use Case (58)             | Code (116)                | 385       | (174)         |                       |      |   |
|              | Use Case (58)             | Code (116)                | 366       | (174)         |                       |      |   |
|              | Use Case (Unclear)        | Code (Unclear)            | 365       | Unclear       |                       |      |   |
| EasyClinic   | Use Case (30)             | Code (47)                 | 93        | (77)          | http://www.coest.org/ | 9    | [S2] [S7] [S8] [S9]<br>[S15] [S16] [S26]<br>[S33] [S35]                     |
|              | Use Case (30)             | Test Case (63)            | 63        | (93)          |                       |      |   |
|              | Use Case (30)             | Test Case (47)            | 63        | (77)          |                       |      |   |
|              | Use Case (30)             | Interaction Diagram (20)  | 26        | (50)          |                       |      |   |
|              | Use Case (30)             | Use Case (30)             | 53        | (60)          |                       |      |   |
|              | Test Case (63)            | Test Case (63)            | 578       | (126)         |                       |      |   |
|              | Test Case (63)            | Code (47)                 | 204       | (110)         |                       |      |   |
|              | Test Case (Unclear)       | Use Case (Unclear)        | 63        | Unclear       |                       |      |   |
|              | Interaction Diagram (20)  | Use Case (30)             | 26        | (50)          |                       |      |   |
|              | Interaction Diagram (20)  | Test Case (63)            | 83        | (83)          |                       |      |   |
|              | Interaction Diagram (20)  | Code (47)                 | 69        | (67)          |                       |      |   |
|              | Interaction Diagram (20)  | Interaction Diagram (20)  | 59        | (40)          |                       |      |   |
|              | Code (47)                 | Code (47)                 | 69        | (94)          |                       |      |   |
|              | Code (47)                 | Test Case (63)            | 202       | (110)         |                       |      |   |
| iTrust       | Use Case (131)            | Code (367)                | 534       | (498)         | http://www.coest.org/ | 9    | [S2] [S8] [S9] [S15]<br>[S18] [S24] [S26]<br>[S35] [S30]                    |
|              | Requirement (131)         | Code (367)                | 399       | (498)         |                       |      |   |
|              | Requirement (131)         | Code (332)                | 535       | (463)         |                       |      |   |

|              |                              |                                 |         |         |   |   |  |
|--------------|------------------------------|---------------------------------|---------|---------|---|---|--|
|              | Requirement (34)             | Code (4913)                     | 307     | (4947)  |   |   |  |
|              | Use Case (Unclear)           | Code (Unclear)                  | 58      | Unclear |   |   |  |
| SMOS         | Use Case (67)                | Code (100)                      | 1045    | (167)   | http://www.coest.org/                         | 8 | [S7] [S8] [S9] [S11]<br>[S14] [S18] [S35]<br>[S26] |
|              | Use Case (67)                | Code (100)                      | 1044    | (167)   |   |   |  |
| CM-1         | High-level requirement (235) | Low-level design document (220) | Unclear | (455)   | http://www.coest.org/                         | 7 | [S2] [S4] [S9] [S13]<br>[S15] [S33] [S35]          |
|              | High-level requirement (22)  | Low-level requirement (53)      | 45      | (75)    |   |   |  |
|              | Requirement (22)             | Design (46)                     | 46      | (68)    |   |   |  |
|              | Requirement (22)             | Design (53)                     | 45      | (75)    |   |   |  |
|              | Requirement (Unclear)        | Use Case (Unclear)              | Unclear | Unclear |   |   |  |
| eAnci        | Use Case (140)               | Code (55)                       | 567     | (195)   | http://www.coest.org/                         | 7 | [S7] [S8] [S9] [S11]<br>[S14] [S35] [S26]          |
|              | Use Case (Unclear)           | Code (Unclear)                  | 554     | Unclear |   |   |  |
| Commons Lang | Test Case (2473)             | Code (596)                      | Unclear | (3069)  | https://github.com/apache/commons-lang        | 4 | [S17] [S22] [S29]<br>[S31]                         |
|              | Test Case (3061)             | Code (3111)                     | 163     | (6172)  |   |   |  |
| JfreeChart   | Test Case (2239)             | Code (953)                      | Unclear | (3192)  | https://github.com/jfree/jfreechart           | 4 | [S17] [S22] [S29]<br>[S31]                         |
|              | Test Case (2244)             | Code (9053)                     | 432     | (11297) |   |   |  |
| MODIS        | High-level requirement (19)  | Low-level requirement (49)      | 41      | (68)    | http://promise.site.uottawa.ca/SERepository   | 4 | [S7] [S8] [S13] [S26]                              |
| MONDRIAN     | Test Case (1546)             | Code (1626)                     | Unclear | (3172)  | https://github.com/pentaho/mondrian           | 3 | [S17] [S22] [S29]                                  |
| Commons Math | Test Case (3493)             | Code (2033)                     | Unclear | (5526)  | https://github.com/apache/commons-math        | 3 | [S17] [S22] [S29]                                  |
| Albergate    | Use Case (17)                | Code (55)                       | 54      | (72)    | http://www.coest.org/                         | 2 | [S11] [S18]  |
|              | Requirement (55)             | Code (17)                       | 53      | (72)    |   |   |  |
| Gson         | Test Case (924)              | Code (757)                      | Unclear | (1681)  | https://github.com/google/gson                | 2 | [S22] [S31]  |
|              | Test Case (1006)             | Code (635)                      | 55      | (1641)  |   |   |  |
| GANNT        | High-level requirement (17)  | Low-level requirement (69)      | 68      | (86)    | http://www.coest.org/                         | 2 | [S15] [S2]   |
| CCHIT        | Requirement (Unclear)        | Requirement (Unclear)           | 1046    | Unclear | http://www.coest.org/                         | 1 | [S30]  |
| EBT          | Requirement (40)             | Test Case (25)                  | 51      | (65)    | http://www.coest.org/                         | 1 | [S18]  |
|              | Requirement (40)             | Code (50)                       | 98      | (90)    |   |   |  |
| LibEST       | Requirement (59)             | Code (11)                       | 204     | (70)    | http://sarec.nd.edu/coest/datasets.html       | 1 | [S18]  |
|              | Requirement (59)             | Test Case (18)                  | 352     | (77)    |   |   |  |
| Selex SI     | Requirement (Unclear)        | Requirement (Unclear)           | 138     | (2500)  | http://www.finmeccanica.com/en/home           | 1 | [S16]  |
| AMBAR!       | Issue (Unclear)              | Issue (Unclear)                 | 942     | (1512)  | http://ambari.apache.org                      | 1 | [S21]  |
| FLEX         | Issue (Unclear)              | Issue (Unclear)                 | 247     | (362)   | http://flex.apache.org                        | 1 | [S21]  |
| HIVE         | Issue (Unclear)              | Issue (Unclear)                 | 5811    | (6730)  | http://hive.apache.org                        | 1 | [S21]  |
| Chess        | Requirement (8)              | Code (752)                      | 563     | (760)   | https://github.com/warpwe/java-chess          | 1 | [S24]  |
| Gantt        | Requirement (18)             | Code (5013)                     | 343     | (5031)  | https://sourceforge.net/projects/ganttproject | 1 | [S24]  |
| JHotDraw     | Requirement (21)             | Code (6520)                     | 439     | (6541)  | https://sourceforge.net/projects/jhotdraw     | 1 | [S24]  |
| CodeSearch   | Commit (Unclear)             | Issue (Unclear)                 | Unclear | Unclear | https://github.com/github/                    | 1 | [S34]  |

|                 |                       |                        |         |         |   |   |       |
|-----------------|-----------------------|------------------------|---------|---------|---|---|-------|
| Net             |                       |                        |         |         | CodeSearchNet   |   |       |
| Pgcli           | Commit (531)          | Issue (522)            | 530     | (1053)  | <a href="https://zenodo.org/record/4511291#.YB3tjy0mbg">https://zenodo.org/record/4511291#.YB3tjy0mbg</a>       | 1 | [S34] |
| Flask           | Commit (752)          | Issue (739)            | 753     | (1491)  |   | 1 | [S34] |
| Keras           | Commit (551)          | Issue (550)            | 51      | (1101)  |   | 1 | [S34] |
| ARC-IT          | Requirement (2395)    | System Functions (802) | 2395    | (3197)  | <a href="https://local.iteris.com/arc-it/index.html">https://local.iteris.com/arc-it/index.html</a>             | 1 | [S5]  |
| Commons IO      | Test Case (994)       | Code (1246)            | 97      | (2240)  | <a href="https://commons.apache.org/proper/commons-io/">https://commons.apache.org/proper/commons-io/</a>       | 1 | [S31] |
| Apache Ant      | Test Case (1830)      | Code (10477)           | 79      | (12307) | <a href="https://ant.apache.org/">https://ant.apache.org/</a>   | 1 | [S31] |
| Mozilla Firefox | Bug Report (34)       | Test Case (113)        | 514     | (147)   | <a href="https://github.com/guilhermemg/trace-links-tc-br">https://github.com/guilhermemg/trace-links-tc-br</a> | 1 | [S6]  |
| Arthas          | Commit (122)          | Issue (167)            | 167     | (289)   | <a href="https://doi.org/10.5281/zenodo.3713256">https://doi.org/10.5281/zenodo.3713256</a>                     | 1 | [S20] |
| bk-cmdb         | Commit (895)          | Issue (1178)           | 1179    | (2073)  |   | 1 | [S20] |
| Canal           | Commit (232)          | Issue (273)            | 273     | (505)   |   | 1 | [S20] |
| Druid           | Commit (1092)         | Issue (1161)           | 1161    | (2253)  |   | 1 | [S20] |
| Emmagee         | Commit (31)           | Issue (32)             | 32      | (63)    |   | 1 | [S20] |
| Nacos           | Commit (132)          | Issue (161)            | 161     | (293)   |   | 1 | [S20] |
| NCNN            | Commit (97)           | Issue (99)             | 99      | (196)   |   | 1 | [S20] |
| Pegasus         | Commit (160)          | Issue (160)            | 160     | (320)   |   | 1 | [S20] |
| QMUl Android    | Commit (70)           | Issue (71)             | 71      | (141)   |   | 1 | [S20] |
| QMUl IOS        | Commit (32)           | Issue (35)             | 35      | (67)    |   | 1 | [S20] |
| Rax             | Commit (560)          | Issue (571)            | 571     | (1131)  |   | 1 | [S20] |
| San             | Commit (186)          | Issue (275)            | 275     | (461)   |   | 1 | [S20] |
| Weui            | Commit (154)          | Issue (159)            | 159     | (313)   |   | 1 | [S20] |
| xLua            | Commit (52)           | Issue (52)             | 52      | (104)   |   | 1 | [S20] |
| Konlpy          | Commit (32)           | Issue (33)             | 33      | (65)    |   | 1 | [S20] |
| Cica            | Commit (25)           | Issue (27)             | 27      | (52)    |   | 1 | [S20] |
| Aws-berline     | Commit (74)           | Issue (74)             | 74      | (148)   |   | 1 | [S20] |
| DASHBUILDER     | Requirement (Unclear) | Requirement (Unclear)  | Unclear | (85)    | <a href="https://issues.jboss.org/browse/DASHBUILDER">https://issues.jboss.org/browse/DASHBUILDER</a>           | 1 | [S13] |
| Maven           | Commit (8205)         | Issue (4728)           | Unclear | (12933) | <a href="https://issues.apache.org/jira/browse/MNG">https://issues.apache.org/jira/browse/MNG</a>               | 1 | [S37] |
| Derby           | Commit (4468)         | Issue (3608)           | Unclear | (8076)  | <a href="https://issues.apache.org/jira/browse/DERBY">https://issues.apache.org/jira/browse/DERBY</a>           | 1 | [S37] |
| Groovy          | Commit (1754)         | Issue (2709)           | Unclear | (4463)  | <a href="https://issues.apache.org/jira/browse/GROOVY">https://issues.apache.org/jira/browse/GROOVY</a>         | 1 | [S37] |
| JBTM            | Requirement (Unclear) | Requirement (Unclear)  | Unclear | (1575)  | <a href="https://issues.jboss.org/browse/JBTM">https://issues.jboss.org/browse/JBTM</a>                         | 1 | [S13] |
| Accumulo        | Requirement (145)     | Code (593)             | 3412    | (738)   | <a href="http://isis.apache.org">http://isis.apache.org</a>   | 1 | [S23] |
| Ignite          | Requirement (41)      | Code (668)             | 15569   | (709)   | <a href="https://ignite.apache.org/">https://ignite.apache.org/</a>   | 1 | [S23] |
| Isis            | Requirement (252)     | Code (2424)            | 11850   | (2676)  | <a href="http://isis.apache.org">http://isis.apache.org</a>   | 1 | [S23] |
| Tika            | Requirement (49)      | Code (72)              | 248     | (121)   | <a href="http://tika.apache.org">http://tika.apache.org</a>   | 1 | [S23] |
| Care2x          | Requirement (Unclear) | Requirement (Unclear)  | 44      | Unclear | <a href="http://www.care2x.org">http://www.care2x.org</a>   | 1 | [S30] |
| ClearHealth     | Requirement (Unclear) | Requirement (Unclear)  | 44      | Unclear | <a href="http://www.clear-health.com">http://www.clear-health.com</a>   | 1 | [S30] |
| Physician       | Requirement (Unclear) | Requirement (Unclear)  | 147     | Unclear | <a href="http://hmss.org/content/files/CTC">hmss.org/content/files/CTC</a>                                      | 1 | [S30] |



|                           |                               |                               |         |         |                               |   |             |
|---------------------------|-------------------------------|-------------------------------|---------|---------|-------------------------------|---|-------------|
|                           |                               |                               |         |         | _use_Case.pdf                 |   |             |
| Trial Implementati<br>ons | Requirement (Unclear)         | Requirement (Unclear)         | 100     | Unclear | http://healthit.hhs.gov       | 1 | [S30]       |
| PatientOS                 | Requirement (Unclear)         | Requirement (Unclear)         | 90      | Unclear | http://www.patientos.org      | 1 | [S30]       |
| PracticeOne               | Requirement (Unclear)         | Requirement (Unclear)         | 34      | Unclear | http://www.practiceone.com    | 1 | [S30]       |
| WorldVista                | Requirement (Unclear)         | Requirement (Unclear)         | 66      | Unclear | http://worldvista.org         | 1 | [S30]       |
| ZOOKEEPER                 | Commit (1719)                 | Issues (1594)                 | Unclear | 1513    | https://zookeeper.apache.org/ | 1 | [S25]       |
| MAHOUT                    | Commit (3925)                 | Issues (1386)                 | Unclear | 1921    | http://mahout.apache.org/     | 1 | [S25]       |
| CHUKWA                    | Commit (847)                  | Issues (819)                  | Unclear | 718     | http://chukwa.apache.org/     | 1 | [S25]       |
| AVRO                      | Commit (1607)                 | Issues (1511)                 | Unclear | 1398    | http://avro.apache.org/       | 1 | [S25]       |
| LANG                      | Commit (5114)                 | Issues (1767)                 | Unclear | 1178    | https://commons.apache.org/   | 1 | [S25]       |
| TEZ                       | Commit (2574)                 | Issues (2901)                 | Unclear | 2503    | http://tez.apache.org         | 1 | [S25]       |
| Pine                      | Requirement (49)              | Use case (51)                 | 250     | (100)   |                               | 2 | [S4] [S36]  |
|                           | Requirement (49)              | Use case (51)                 | 246     | (100)   |                               |   |             |
| SafeDrink *               | Functional requirement (170)  | Code (173)                    | Unclear | (343)   |                               | 2 | [S3] [S12]  |
| SmartTrip *               | Functional requirement (214)  | Code (266)                    | Unclear | (480)   |                               | 2 | [S3] [S12]  |
| BlueWallet *              | Functional requirements (184) | Code (374)                    | Unclear | (558)   |                               | 2 | [S3] [S12]  |
| Drools                    | Requirement (Unclear)         | Requirement (Unclear)         | Unclear | (486)   |                               | 2 | [S13] [S37] |
|                           | Commit (3735)                 | Issue (3992)                  | Unclear | (7727)  |                               |   |             |
| Lauesen                   | Requirement (Unclear)         | Requirement (Unclear)         | 116     | Unclear |                               | 1 | [S30]       |
| Joda-Time                 | Test Case (3779)              | Code (522)                    | Unclear | (4301)  |                               | 1 | [S22]       |
| PTC                       | Requirement (1651)            | Design (466)                  | 1387    | (2117)  |                               | 1 | [S27]       |
| Lucene                    | Code (5097)                   | Software documentation (1899) | 2137    | (6996)  |                               | 1 | [S32]       |
| ArgoUML                   | Test Case (554)               | Code (2404)                   | Unclear | (2958)  |                               | 1 | [S22]       |
| Waterloo                  | Feature (Unclear)             | Use Case (Unclear)            | Unclear | Unclear |                               | 1 | [S33]       |
| PMD                       | Test Case (825)               | Code (1608)                   | Unclear | (2433)  |                               | 1 | [S22]       |
| Clafer Tools              | Feature annotation (14000)    | Code (Unclear)                | Unclear | Unclear |                               | 1 | [S28]       |
| AIRFLOW                   | Requirement (Unclear)         | Requirement (Unclear)         | Unclear | (629)   |                               | 1 | [S13]       |
| ANY23                     | Requirement (Unclear)         | Requirement (Unclear)         | Unclear | (182)   |                               | 1 | [S13]       |
| Pig                       | Commit (4839)                 | Issue (2012)                  | Unclear | (6851)  |                               | 1 | [S37]       |
| Infinispan                | Commit (4778)                 | Issue (2058)                  | Unclear | (6836)  |                               | 1 | [S37]       |
| IMMUTANT                  | Requirement (Unclear)         | Requirement (Unclear)         | Unclear | (404)   |                               | 1 | [S13]       |
| CAF                       | Requirement (Unclear)         | Model (Unclear)               | Unclear | Unclear |                               | 1 | [S19]       |
| Dataset1 *                | Requirement (762)             | Requirement (521)             | 367     | (1283)  |                               | 1 | [S10]       |
| Dataset2 *                | Requirement (2060)            | Requirement (4188)            | 817     | (6248)  |                               | 1 | [S10]       |

\* present that author uses a pseudonym of the name of dataset for confidentiality agreements

## 2. Search process record

| Database       | Number of searches | Number of repetitions in each database | Number of each database (After deleting repetitions) | Number of repetitions in all databases | Total number (After deleting repetitions) |
|----------------|--------------------|--|--|--|---|
| ACM            | 96                 | 1                                      | 69   | 227                                    | 56  |
| Springer       | 210                | 0                                      | 171  |  | 132                                       |
| Science Direct | 136                | 20                                     | 113  |  | 80  |
| EI             | 674                | 38                                     | 596  |  | 457                                       |
| IEEE           | 324                | 67                                     | 243  |  | 240                                       |
| Total          | 1440               | 126                                    | 1192   |  | 965                                       |

Excute inclusion/exclusion criteria

| Database       | apply criteria (ISC1-ISC3, ESC1-ESC4) | apply criteria(ISC4-ISC5, ESC5-ESC6) in title, abstract, keywords | apply criteria(ISC4-ISC5, ESC5-ESC6) in full article | Snowballing | final |
|----------------|---------------------------------------|---|--|-------------|-------|
| ACM            | 625                                   | 184   | 34   | 3           | 37    |
| Springer       |                                       |   |  |             |       |
| Science Direct |                                       |   |  |             |       |
| EI             |                                       |   |  |             |       |
| IEEE           |                                       |   |  |             |       |
| Total          |                                       |   |  |             |       |

### 1.7 Search records

Digital Libraries:

| Database       | Website   |
|----------------|---|
| ACM            | <a href="https://dl.acm.org/">https://dl.acm.org/</a>                                 |
| Springer       | <a href="https://www.springer.com/">https://www.springer.com/</a>                     |
| Science Direct | <a href="https://www.sciencedirect.com/">https://www.sciencedirect.com/</a>           |
| EI             | <a href="https://www.engineeringvillage.com/">https://www.engineeringvillage.com/</a> |
| IEEE           | <a href="https://ieeexplore.ieee.org/">https://ieeexplore.ieee.org/</a>               |

Search terms:

|    |                            |    |                          |
|----|----------------------------|----|--------------------------|
| P1 | software traceability      | I1 | machine learning         |
| P2 | software trace             | I2 | ML                       |
| P3 | software tracing           | I3 | supervised learning      |
| P4 | traceability link recovery | I4 | unsupervised learning    |
|    |                            | I5 | semi-supervised learning |

|  |  |    |                        |
|--|--|----|------------------------|
|  |  | I6 | reinforcement learning |
|--|--|----|------------------------|

## (1) ACM

|   |          |
|---|----------|
|   | Anywhere |
| (P1 OR P2 OR P3 OR P4)<br>AND<br>(I1 OR I2 OR I3 OR I4 OR I5 OR I6) | 96       |

### Advanced search:

("software traceability" OR "software trace" OR "software tracing" OR "traceability link recovery") AND ("machine learning" OR "ML" OR "supervised learning" OR "unsupervised learning" OR "semi-supervised learning" OR "reinforcement learning")

### Screenshot of search process in ACM:

ACM DIGITAL LIBRARY Association for Computing Machinery

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("software traceability" OR "software trace" OR "software tracing" OR "traceability link recovery") AND ("machine learning" OR "ML" OR "supervised learning" OR "unsupervised learning" OR "semi-supervised learning" OR "reinforcement learning")

# Search Results

("software traceability" OR "software trace" OR "software tracing" OR "traceability link recovery") AND ("machine learning" OR "ML" OR "supervised learning" OR "unsupervised learning" OR "semi-supervised learning" OR "reinforcement learning")

Advanced Search

96 Results for: *[[All: "software traceability"] OR [All: "software trace"] OR [All: "software tracing"] OR [All: "traceability link recovery"]]] AND [[All: "machine learning"] OR [All: "ml"] OR [All: "supervised learning"] OR [All: "unsupervised learning"] OR [All: "semi-supervised learning"] OR [All: "reinforcement learning"]]]*

Edit Search Save Search

Searched The ACM Full-Text Collection (685,729 records) | Expand your search to The ACM Guide to Computing Literature (3,448,968 records) RSS

RESULTS VIDEOS SOFTWARE Showing 1 - 20 of 96 Results

Select All per page: 10 20 50 Relevance

SHORT-PAPER August 2017 Automating traceability link recovery through classification Chris Mills

## (2) Springer

|   |                         |
|---|-------------------------|
|   | Keywords+Title+Abstract |
| (P1 OR P2 OR P3 OR P4)<br>AND<br>(I1 OR I2 OR I3 OR I4 OR I5 OR I6) | 210                     |

### Advanced search:

("software traceability" OR "software trace" OR "software tracing" OR "traceability link recovery") AND ("machine learning" OR "ML" OR "supervised learning" OR "unsupervised learning" OR "semi-supervised learning" OR "reinforcement learning")

### Screenshot of search process in Springer:

("software traceability" OR "software trace" OR "software tracing" OR "traceability link recovery") AND ("machine learning" OR "ML" OR "supervised")

New Search



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Include Preview-Only content

### Refine Your Search

#### Content Type

|                        |     |
|------------------------|-----|
| Article                | 115 |
| Chapter                | 56  |
| Book                   | 35  |
| Conference Paper       | 32  |
| Conference Proceedings | 28  |
| Protocol               | 4   |

#### Discipline

see all

|                          |     |
|--------------------------|-----|
| Computer Science         | 132 |
| Engineering              | 29  |
| Medicine & Public Health | 22  |
| Biomedicine              | 9   |
| Life Sciences            | 6   |

#### Subdiscipline

see all

|  |    |
|--|----|
| Software Engineering/Programming and Operating Systems | 75 |
| Programming Languages, Compilers, Interpreters         | 58 |

210 Result(s) for ("software traceability" OR "software trace" OR "software tracing" OR "traceability link recovery") AND ("machine learning" OR "ML" OR "supervised")

Page 1 of 11

Sort By

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Date Published

Book and Conference Proceedings

## Advances in Artificial Intelligence and Applied Cognitive Computing

Proceedings from ICAI'20 and ACC'20

Hamid R. Arabnia, Ken Ferens... in *Transactions on Computational Science and Computational Intelligence* (2021)


Book and Conference Proceedings

## Computer Networks, Big Data and IoT

Proceedings of ICCBI 2021

Dr. A. Pasumpon Pandian... in *Lecture Notes on Data Engineering and Communications Technologies* (2022)


Article

## Eye movements in software traceability link recovery

Information Retrieval (IR) approaches, such as Latent Semantic Indexing (LSI) and Vector Space Model (VSM), are commonly applied to recover software traceability links. Recently, an approach based on

### (3) Science Direct

|                                 | Title+Abstract+Keywords |
|---------------------------------|-------------------------|
| (P1 OR P2 OR P3 OR P4) AND (I1) | 63                      |
| (P1 OR P2 OR P3 OR P4) AND (I2) | 59                      |
| (P1 OR P2 OR P3 OR P4) AND (I3) | 7                       |
| (P1 OR P2 OR P3 OR P4) AND (I4) | 2                       |
| (P1 OR P2 OR P3 OR P4) AND (I5) | 1                       |
| (P1 OR P2 OR P3 OR P4) AND (I6) | 4                       |
| <b>Total</b>                    | <b>136</b>              |

#### ■ Advanced search((P1 OR P2 OR P3 OR P4) AND (I1)):

("software traceability" OR "software trace" OR "software tracing" OR "traceability link recovery") AND ("machine learning" OR "ML" OR "supervised")

Screenshot of search process in Scient Direct:

Find articles with these terms


Year: 2013-2022 [×](#)

Title, abstract, keywords: (software traceability OR software trace OR software tracing OR traceability link r... [×](#)
[Advanced search](#)

63 results

[sorted by relevance](#) | [date](#)

Refine by:

Years

☐ 2022 (14)

☐ 2021 (18)

☐ 2020 (6)

[Show more](#) [v](#)

Article type [?](#)
☐ Research article (1)

Research article

Traceability Link Recovery between Requirements and Models using an Evolutionary Algorithm Guided by a Learning to Rank Algorithm: Train control and management case

Journal of Systems and Software, 15 January 2020, ...

Ana C. Marcén, Raúl Lapeña, ... Carlos Cetina

Book chapter

Chapter 10: Error Traceability and Error Prediction using Machine Learning Techniques to Improve the Quality of Vehicle Modeling in Computer-Aided Engineering

Cognitive Computing for Human-Robot Interaction, 20 August 2021, ...

A. Anny Leema, Krishna Sai Narayana, Subramani Sellamani

## ■ Advanced search((P1 OR P2 OR P3 OR P4) AND (I2)):

(software traceability OR software trace OR software tracing OR traceability link recovery) AND (ML)

**Screenshot of search process in Scient Direct:**

Find articles with these terms


Year: 2013-2022 [×](#)

Title, abstract, keywords: (software traceability OR software trace OR software tracing OR traceability link r... [×](#)
[Advanced search](#)

59 results

[sorted by relevance](#) | [date](#)

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Years

☐ 2022 (13)

☐ 2021 (6)

☐ 2020 (6)

[Show more](#) [v](#)

Article type [?](#)

Research article

Multilayered review of safety approaches for machine learning-based systems in the days of AI

Journal of Systems and Software, 6 March 2021, ...

Sangeeta Dey, Seok-Won Lee

Research article

Synthesis and application of molecularly imprinted nanoparticles combined ultrasonic assisted for highly selective solid phase extraction trace amount of celecoxib from human plasma samples using design expert (DXB) software

Ultrasonics Sonochemistry, November 2016, ...

Maryam Arabi, Mehrorang Ghaedi, ... Hamideh Asadollahzadeh

## ■ Advanced search((P1 OR P2 OR P3 OR P4) AND (I3)):

(software traceability OR software trace OR software tracing OR traceability link recovery) AND (supervised learning)

**Screenshot of search process in Scient Direct:**

Find articles with these terms



Year: 2013-2022 ✕

Title, abstract, keywords: (software traceability OR software trace OR software tracing OR traceability link r... ✕

Advanced search

7 results

sorted by relevance | date

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Years

☐ 2022 (3)

☐ 2021 (1)

☐ 2020 (2)

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Open access

Quantitative neuronal morphometry by supervised and unsupervised learning

STAR Protocols, 30 September 2021, ...

Kayvan Bijari, Gema Valera, ... Giorgio A. Ascoli

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Research article

Proximal Instance Aggregator networks for explainable security vulnerability detection

Future Generation Computer Systems, 18 April 2022, ...

Hariharan M., Sathish Kumar C., ... R. Karthik

## ■ Advanced search((P1 OR P2 OR P3 OR P4) AND (I4)):

(software traceability OR software trace OR software tracing OR traceability link recovery) AND (unsupervised learning)

### Screenshot of search process in Scient Direct:

Find articles with these terms



Year: 2013-2022 ✕

Title, abstract, keywords: (software traceability OR software trace OR software tracing OR traceability link r... ✕

Advanced search

2 results

sorted by relevance | date

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Years

☐ 2021 (1)

☐ 2019 (1)

Article type ?

☐ Research articles (1)

☐ ...

Open access

Quantitative neuronal morphometry by supervised and unsupervised learning

STAR Protocols, 30 September 2021, ...

Kayvan Bijari, Gema Valera, ... Giorgio A. Ascoli

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Research article

Fire resistance evaluation through artificial intelligence - A case for timber structures

Fire Safety Journal, 8 February 2019, ...

M. Z. Naser

## ■ Advanced search((P1 OR P2 OR P3 OR P4) AND (I5)):

(software traceability OR software trace OR software tracing OR traceability link recovery) AND (semi-supervised learning)

### Screenshot of search process in Scient Direct:

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Year: 2013-2022 ✕

Title, abstract, keywords: (software traceability OR software trace OR software tracing OR traceability link r... ✕

Advanced search

1 result found

Refine by:

Years

☐ 2022 (1)

Research article

Workload forecasting and energy state estimation in cloud data centres: ML-centric approach


Future Generation Computer Systems, 28 October 2021, ...

Tahseen Khan, Wenhong Tian, ... Rajkumar Buyya

■ Advanced search((P1 OR P2 OR P3 OR P4) AND (I6)):

(software traceability OR software trace OR software tracing OR traceability link recovery) AND (reinforcement learning)

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Year: 2013-2022

Title, abstract, keywords: (software traceability OR software trace OR software tracing OR traceability link r...

Advanced search

4 results

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Years

☐ 2022 (2)

☐ 2021 (1)

☐ 2020 (1)

Publication title

☐ Journal of Parallel and Distributed Computing (2)

Research article

Learning to make auto-scaling decisions with heterogeneous spot and on-demand instances via reinforcement learning

Information Sciences, 21 October 2022, ...

Liduo Lin, Li Pan, Shijun Liu

Research article

Open access

A dynamic planning model for deploying service functions chain in fog-cloud computing

Journal of King Saud University - Computer and Information Sciences, 19 July 2022, ...

Yongheng Zhang, Feng Zhang, ... Amin Rezaeipana

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(4) EI

|   | Subject/Title/Abstract |
|---|------------------------|
| (P1 OR P2 OR P3 OR P4)<br>AND<br>(I1 OR I2 OR I3 OR I4 OR I5 OR I6) | 674                    |

Expert search:

(software traceability OR software trace OR software tracing OR traceability link recovery) AND (machine learning OR ML OR supervised learning OR unsupervised learning OR semi-supervised learning OR reinforcement learning)

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 Engineering Village

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Expert search:

((software traceability OR software trace OR software tracing OR traceability link recovery) AND (machine learning OR ML OR supervised learning OR unsupervised learning OR semi-supervised learning OR reinforcement learning)) WN KY

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Sort by

Autostemming

Search codes

Browse indexes

674 records found in Compendex for 2013-2022: (((software traceability OR software trace OR software tracing OR traceability link recovery) AND (machine learning OR ML OR supervised learning OR unsupervised learning OR semi-supervised learning OR reinforcement learning)) WN KY)

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Gold (42)

Hybrid Gold (7)

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1. Semi-supervised pre-processing for learning-based traceability framework on real-world software projects (Open Access)

Dong, Liming (State Key Laboratory of Novel Software Technology, Software Institute, Nanjing University, Jiangsu, Nanjing, China); Zhang, He; Liu, Wei; Weng, Zhiluo; Kuang, Hongyu Source: ESEC/FSE 2022 - Proceedings of the 30th ACM Joint Meeting European Software Engineering Conference and Symposium on the Foundations of Software Engineering, p 570-582, November 7, 2022, ESEC/FSE 2022 - Proceedings of the 30th ACM Joint Meeting European Software Engineering Conference and Symposium on the Foundations of Software Engineering

Database: Compendex

Document type: Conference article (CA)

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2. Tracing with Less Data: Active Learning for Classification-Based Traceability Link Recovery

Mills, Chris (Department of Computer Science, Florida State University, Tallahassee, FL, United States); Escobar-Avila, Javier; Bhattacharya, Aditya; Kondusko, Gionnir; Chakraborty, Shayok; Haiduc, Sonia Source: Proceedings - 2019 IEEE International Conference on Software Maintenance and Evolution, ICSME 2019, p 103 Feedback 2019,

## (5) IEEE

|   | Title | Abstract | Index terms |
|---|-------|----------|-------------|
| (P1 OR P2 OR P3 OR P4)<br>AND<br>(I1 OR I2 OR I3 OR I4 OR I5 OR I6) | 2     | 159      | 163         |
| <b>Total</b>  | 324   |          |             |

### ■ Command Search(Title):

("Document Title":software traceability OR "Document Title":software trace OR "Document Title":software tracing OR "Document Title":traceability link recovery) AND ("Document Title":machine learning OR "Document Title":ML OR "Document Title":supervised learning OR "Document Title":unsupervised learning OR "Document Title":semi-supervised learning OR "Document Title":reinforcement learning)

### Screenshot of search process in IEEE:

The screenshot displays the IEEE Xplore search results page. At the top, the IEEE Xplore logo and navigation links (Browse, My Settings, Help, Institutional Sign In) are visible. A search bar with the query "(("Document Title":software traceability OR "Document Title":software trace OR "Document Title":software tracing OR "Document Title":traceability link recovery) AND ("Document Title":machine learning OR "Document Title":ML OR "Document Title":supervised learning OR "Document Title":unsupervised learning OR "Document Title":semi-supervised learning OR "Document Title":reinforcement learning))" is shown. Below the search bar, the results are displayed, including a list of search results with titles, authors, and publication details. The first result is "Trace-by-classification: A machine learning approach to generate trace links for frequently occurring software artifacts" by Mateusz Wieloch; Sorawit Amornborvornwong; Jane Cleland-Huang, published in 2013. The second result is "Analysis of Software Bug Prediction and Tracing Models from a Statistical Perspective Using Machine Learning" by Darshana Tambe; Lata Ragha, published in 2022. The interface also includes filters for Year (2013 to 2022) and Author, and a sidebar with promotional banners for IEEE Xplore Full-Text access and the IEEE Climate Change Collection.

### ■ Command Search(Abstract):

("Abstract":software traceability OR "Abstract":software trace OR "Abstract":software tracing OR "Abstract":traceability link recovery) AND ("Abstract":machine learning OR "Abstract":ML OR "Abstract":supervised learning OR "Abstract":unsupervised learning OR "Abstract":semi-supervised learning OR "Abstract":reinforcement learning)

### Screenshot of search process in IEEE:



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 ("Abstract":machine learning OR "Abstract":ML OR "Abstract":supervised learning OR "Abstract":unsupervised learning OR "Abstract":semi-supervised learning OR "Abstract":reinforcement learning) x

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Guoshuai Zhao; Tong Li; Zhen Yang  
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