

TABLE I: Data extraction table

ID	RQ1	RQ2	RQ3	RQ4
[6]	Jdeodorant	Long Method, Feature Envy, Type Checking, Duplicated Code, God Class	NA	NA, NA, Java
[9]	MTV-Checker	Meddling Model, Meddling View, Brain Persistence Method+, Improper Use of Manager, Laborious Persistence Method	Tree-based	NA, No, Python
[5]	Jdeodorant	NA	NA	NA, NA, Java
[13]	JSNose, aDoctor, Jdeodorant, JSPIRIT, DECOR, Stench Blossom	JSNose (Lazy Object, Long Message Chain, Closure, Coupling, Empty Cash, Global Variable, Large Object, Long Method, Long Parameter List, Nested Callback, Refused Bequest, Switch Statement, Dead Code), aDoctor, Jdeodorant, JSPIRIT, DECOR, Stench Blossom (NA)	NA	JSNose (NA, NA, JavaScript), aDoctor, Jdeodorant, JSPIRIT, DECOR, Stench Blossom (NA, NA, NA)
[18]	DECOR, Jdeodorant	DECOR (Blob+, God Class+, Spaghetti Code, Class, Data Should Be Private, Complex Class+, Long Method+), Jdeodorant (Feature Envy+, State Checking+, Long Method+, Blob+)	DECOR (Rule-based), Jdeodorant (Metric-based)	DECOR (Yes, NA, Java), Jdeodorant (NA, NA, Java)
[26]	GodExpo	God Class+	Metric-based	Yes, No, Golang
[19]	Arcan	Unstable Dependency, Hub-Like Dependency, Cyclic Dependency, Feature Concentration	Graph-based	NA, NA, Java
[8]	JSPIRIT, Jdeodorant, FindSmells	JSPIRIT (Large Class+, Long Method+, Data Class+, Refused Bequest+, Feature Envy+), Jdeodorant (God Class, God Method, Feature Envy, Switch Statement), FindSmell (NA)	JSPIRIT(NA), Jdeodorant (NA), FindSmells (Rule-based)	JSPIRIT(NA, No, Java), Jdeodorant (NA, NO, Java), FindSmells (NO, NA, NA)
[3]	DECOR, iPlasma, inCode, inFusion, jDeodorant, PMD, jCOSMO, Analyst4j, Cultivate (from jTransformer suite), Reek, RevJava, SA4J, Together, Stench Blossom, ConcernReCS, SourceMiner, BSDT, JCodeCanine,, CodeVizard, JSNose, Hist-Inspect, PTIDEJ suite (containing DECOR and its evolution DETEX), BLOP, JSPIRIT, SpIRIT, CCFinder, Sissy, Understand, Pysmell	inFusion (Brain Method+, Cyclic Dependencies+, Data Class+, Feature Envy+, God Class+, Intensive Coupling+, Missing Template Method+, Refused Bequest+, Sibling Duplication+, Shotgun Surgery+, SAP-Breakers+, Internal Duplication+, External Duplication+, Blob+, Blob Operation+, Data Clump+, Message Chain+, Distorted Hierarchy+, Schizophrenic Class+, Tradition Breaker+, Unstable Dependencies+), inCode (Data Class+, Data Clump+, Duplicate Code+, Feature Envy+, God Class+, God Method+, Misplaced Class+, Refused Bequest+, Shotgun Surgery+, Message Chain+, Schizophrenic Class+), iPlasma (Brain Class+, Brain Method+, Data Class+, Dispersed Coupling+, Feature Envy+, God Class+, Intensive Coupling+, Shotgun Surgery+, Refused Bequest+, Tradition Breaker+, Long Method+, Long Parameter List+, Speculative Generality+), JDeodorant (Feature Envy+, God Class+, Long Method+, Type Checking, Duplicate code), PMD (Large Class+, Long Method+, Long Parameter List+), DECOR (Large Class+, Lazy Class+, Long Method+, Long Parameter List+, Refused Bequest+, Speculative Generality, Message Chain+, Shotgun Surgery+, Duplicate Code, Comments, Data Class+, No Polymorphism, Global Variable, Controller Class+, Procedural Class, Low Cohesion+, Divergent Change+, Blob+, Spaghetti Code+, Functional Decomposition, Swiss Army Knife), jCOSMO, Analyst4j, Cultivate (from jTransformer suite), Reek, RevJava, SA4J, Together, Stench Blossom, ConcernReCS, SourceMiner, BSDT, JCodeCanine,, CodeVizard, JSNose, Hist-Inspect, PTIDEJ suite (containing DECOR and its evolution DETEX), BLOP, JSPIRIT, SpIRIT, CCFinder, Sissy, Understand, Pysmell (NA)	inFusion (Metric-based), inCode (Metric-based), iPlasma (Metric-based), Jdeodorant (Tree-based), PMD (Rule-based), DECOR (Metric-based), jCOSMO, Analyst4j, Cultivate (from jTransformer suite), Reek, RevJava, SA4J, Together, Stench Blossom, ConcernReCS, SourceMiner, BSDT, JCodeCanine, CodeVizard, JSNose, Hist-Inspect, PTIDEJ suite (containing DECOR and its evolution DETEX), BLOP, JSPIRIT, SpIRIT, CCFinder, Sissy, Understand, Pysmell (NA)	inFusion (NA, No, (Java, C++, C)), inCode (NA, No, (Java, C++, C)), iPlasma(NA, No, (Java, C++)), Jdeodorant (NA, No, Java), PMD (NA, NA, (Java, C, C++, C#, PHP, Ruby, Python etc.)), DECOR (NA, NA, Java), CCFinder (NA, NA (COBOL, Visual Basic)), Pysmell(NA, NA, Python), Sissy (NA, NA, (Object-Pascal, Delphi)), jCOSMO, Analyst4j, Cultivate (from jTransformer suite), Reek, RevJava, SA4J, Together, Stench Blossom, ConcernReCS, SourceMiner, BSDT, JCodeCanine, CodeVizard, JSNose, Hist-Inspect, PTIDEJ suite (containing DECOR and its evolution DETEX), BLOP, JSPIRIT, SpIRIT, Understand, (NA, NA, NA)
[2]	iPerfDetector	Accessing data models on the UI thread, Updating UIs on background threads, Applying UI blurring effect inefficiently, Applying UI transparency inefficiently, Retain cycle	Tree-based	Yes, No, Swift
[10]	cASpER	Feature Envy+, Misplaced Class+, Blob+, Promiscuous Package	Rule-based, Text-based	Yes, No, Java

ID	RQ1	RQ2	RQ3	RQ4
[15]	Droidlens	Internal Getter/Setter+, Leaking Inner Class+, Member Ignoring Method+, No Low Memory Resolver+, HashMap Usage+, Data Transmission Without Compression+, Inefficient Data Format And Parser+, Unclosed Closeable+, Inefficient SQL Query+, Leaking Thread+, Slow Loop+, Durable Wakelock+, Public Data+, Rigid Alarm-Manager+, Debuggable Release+, Heavy Broadcast Receiver+, Heavy Service Start+, Set Config Changes+	Metric-based	NA, No, Java
[4]	TAJSlint	Argument Count Mismatch+,Argument Type Mismatch, Array Length Assignment, Primitive Property Assignment, Negative Array Index, Udeclared Variables, Duplicate Declaration+, Unused Declaration+, Unreachable Code, Loosely-typed Variable, Lon Method Chain+, Large/Lazy Class+, Long parametr list+, Cyclomethc Complexity+	Metric-based, Rule-based	Yes, NA, JavaScript
[23]	XData grading system	Long Method+	Metric-based, Graph-based	No, NA, Language independent
[24]	NiCad, CPD, iClones, TCORE	Code clones	NiCad (Text-based), CPD (Token-based), iClones (Token-based, Tree-based), TCORE (Tree-based, Graph-based)	NiCad (Yes, No, Java), CPD (Yes, No, Java), iClones (Yes, No, Java), TCORE (Yes, No, Java)
[7]	No name, Table E1	Internal Getter/Setter+, Leaking Inner Class+, Member Ignoring Method+, No Low Memory Resolver+, HashMap Usage+, Data Transmission Without Compression+, Inefficient Data Format And Parser+, Unclosed Closeable+, Inefficient SQL Query+, Leaking Thread+, Slow Loop+, Durable Wakelock+, Public Data+, Rigid Alarm-Manager+, Debuggable Release+, Heavy Broadcast Receiver+, Heavy Service Start+, Set Config Changes+, Large Class+, Data Class+, Long Method+, Lazy Class+, Long Parameter List+, Feature Envy+, Refused Bequest+, Switch Statements+, Duplicate Code+, Message Chain+, Parallel Inheritance Hierarchy+, Speculative Generality+, Shotgun Surgery+, Primitive Obsession+, Temporary Field+, Middle Man+, Divergent Change+, Alternative Classes with Different Interface+, Inappropriate Intimacy+, Data Clump+ Table E1	No name (Metric-based), Tools from Table E1 (NA)	Yes, No, Java Table E1
[21]	Designite, Ndepend, Jarchitect, Lattix Architect, SotoArc, Structure101	Designite (Broken Hierarchy, Broken Modularization, Cyclically-dependent Modularization, Duplicate Abstraction, Hub-like Modularization, Imperative Abstraction, Insufficient Modularization, Multipath Hierarchy, Rebellious Hierarchy, Unnecessary Abstraction, Unutilized Abstraction, Wide Hierarchy, Cyclic Dependency+, Unstable Dependency+, God Component+, Feature Concentration+, Scattered Functionality+, Dense Structure+), Ndepend (Insufficient modularization, multifaceted abstraction, unutilized, abstraction, deep hierarchy), Jarchitect (Insufficient modularization, multifaceted abstraction, unutilized abstraction, deep hierarchy)	Ndepend (Metric-based), Jarchitect (Metric-based), Lattix Architect (Rule-based), SotoArc (Graph-based), Structure101 (Graph-based), Designite (Rule-based)	Designite (Yes, Yes, C#), Ndepend (Yes, NA, C#), Jarchitect (Yes, NA, C#), Lattix Architect, SotoArc, Structure101 (NA, NA, NA)

ID	RQ1	RQ2	RQ3	RQ4
[1]	<p>ADOCTOR, Arcan, Asta, c-JRefRec, CBCD, CCFinder, ClemanX, CloneDetection, Coogle (Eclipse plugin), DECKARD, DECOR, Dup, BSDT (Eclipse plugin), JCodeCanine (Eclipse plugin), LCAAnalyzer (Eclipse plugin), SCOOP (Eclipse plugin), FindSmells, Gemini, HIST, HULK, jCOSMO, Jdeodorant, Jplag, JBOO, JSNOSE, JSPIRIT, LAPD, LBSDetectors, LIME (Eclipse plugin), NICAD, PAD, Paprika, PC Detector, PRODETECTION, Pysmell, Smell Platform, SourcererCC, TACO, DuplicationDetector, XIAO</p>	<p>ADOCTOR (Data transmission without compression, Debuggable release, Durable wakelock, Inefficient data format and parser, Inefficient data structure, Inefficient SQL query, Internal getter and setter, Leaking inner class, leaking thread, Memberignoring method, No low memory resolver, Public data, Rigid alarm manager, Slow loop, Unclosed closable), Arcan (Unstable dependency+, hub-like dependency+, cyclic dependency+), Asta (Code clones), c-JRefRec (Feature envy), CBCD (Code clones), CCFinder (Code clones), ClemanX (Code clones), CloneDetection (Code clones), Coogle (Code clones), DECKARD (Code clones), DECOR(Blob, Functional decomposition, Spaghetti code, Swiss Army Knife), Dup (Code clones), BSDT (Large class+, Long method+, Data class+, Parallel inheritance hierarchies+, Long parameter list+, Switch statements+, Lazy class+), JCodeCanine (Feature envy+), LCAAnalyzer (Nullable objects, explicit cast, wrong verbosity level, Dup1, Dup2, and malformed output), SCOOP (Hereditary anomaly, replicated external network, multiple-anomaly syndrome), FindSmells (Large class, Long method, Data class, Feature envy, and Refused bequest), Gemini (Code clones), HIST (Divergent change, Shotgun surgery, Parallel inheritance, Blob, Feature envy), HULK (God class, Blob, Swiss Army knife, Spaghetti code), jCOSMO (Instanceof, Typecast), Jdeodorant (Feature envy), Jplag (Code clones), JBOO (Use case clones), JSNOSE (Closure smells, Coupling between JavaScript, HTML, and CSS, Excessive global variables, Long message chain, Nested Callback, Refused bequest, Empty catch, Large/Lazy object, Long method/Function, Long parameter list, Switch statement, Unused/dead code), JSPIRIT (Brain class+, Brain method+, Data class+, Dispersed coupling+, Feature envy, God class+, Intensive coupling+, Refused parent bequest+, Shotgun surgery+, Tradition breaker), LAPD (Linguistic antipatterns), LBSDetectors (Odd grammatical structure, Term used to name both the whole and its parts, Inconsistent identifier use, Useless type indication, Identifier construction rules), LIME (Code clones), NICAD (Code clones), PAD (Empty semitrucks, Circuitous treasure hunt, Blob), Paprika (Blob, Swiss Army knife, Complex class, Long method, Internal getter/setter, No low memory resolver, Member ignoring method, Leaking inner class), PC Detector (Code clones), PRODETECTION (God class, Shotgun surgery, Refused bequest, Feature envy, God method, Misplaced class, God package, Wide subsystem, Interface, Data class), Pysmell (Large class+, Long parameter list+, Long method+, Long message chain+, Long scope chaining+, Long Base class list+, Useless exception handling+, Long lambda function+, Complex list comprehension+, Long element chain+, Long ternary+, Conditional expression+), Smell Platform (Long parameter list, Long method, God class, Feature envy), SourcererCC (Code clones), TACO (Long method, Feature envy, Blob, Promiscuous package, Misplaced class), DuplicationDetector (Code clones), XIAO (Code clones)</p>	<p>ADOCTOR (Rule-based), Arcan (Metrics-based), Asta (Token-based), c-JRefRec (Graph-based), CBCD (Graph-based), CCFinder (Tree-based), ClemanX (Tree-based), CloneDetection (Token-based),Coogle (Metrics-based), DECKARD (Tree-based), DECOR (Rule-based), Dup (Token-based), BSDT (Metrics-based), JCodeCanine (Metrics-based), LCAAnalyzer (Tree-based), SCOOP (Rule-based), FindSmells (Metrics-based), Gemini (Metrics-based), HIST (Rule-based), HULK (Rule-based), jCOSMO (Tree-based), Jdeodorant (Tree-based), Jplag (NA), JBOO (Graph-based), JSNOSE (Metrics-based), JSPIRIT (Metrics-based), LAPD (Text-based), LBSDetectors (Text-based), LIME (NA), NICAD (Text-based), PAD (Tree-based), Paprika (Graph-based), PC Detector (Token-based), PRODETECTION (Rule-based), Pysmell (Metrics-based), Smell Platform (Rule-based), SourcererCC (Token-based), TACO (Text-based), DuplicationDetector (Tree-based), XIAO (Text-based)</p>	<p>ADOCTOR (NA, NA, Java), Asta (NA, NA, NA), c-JRefRecCBCD (NA, NA, Java), CBCD (NA, NA, NA), CCFinder (NA, NA, (Java, C, C++)), ClemanX (NA, NA, NA), CloneDetection (NA, NA, (Java, C, C++)), Coogle (NA, NA, Java), DECKARD (NA, NA, NA), DECOR (NA, NA, NA), Dup (NA, NA, NA), BSDT (NA, NA, NA), JCodeCanine (NA, NA, Java), LCAAnalyzer (NA, NA, Java), SCOOP (NA, NA, Java), FindSmells (NA, NA, NA), Gemini (NA, NA, NA), HIST (NA, NA, Java), HULK (NA, NA, Java), jCOSMO (NA, NA, Java), Jdeodorant (NA, NA, Java, Jplag (NA, NA, (C, C++))), JBOO (NA, NA, NA), JSNOSE (NA, NA, NA), JSPIRIT (NA, NA, Java), LAPD (NA, NA, Java), LBSDetectors (NA, NA, NA), LIME (NA, NA, NA), NICAD (NA, NA, NA), PAD (NA, NA, NA), Paprika (NA, NA, Java), PC Detector (NA, NA, (C, C++)), PRODETECTION (NA, NA, Java), Pysmell (NA, NA, NA), Smell Platform (NA, NA, NA), SourcererCC (NA, NA, (Java, C)), TACO (NA, NA, NA), DuplicationDetector (NA, NA, NA), XIAO (NA, NA, (C, C++))</p>

ID	RQ1	RQ2	RQ3	Metric-based	RQ4
[17]	No name	Empty catch block, Hard-coded secret, Empty password, Insecure hash algorithm, Smelly methods usage	Text-based, based		No, No, Java
[22]	Grace	Structural coupling, Co-evolution coupling	Graph-based		NA, No, Language independent
[14]	DLFinder	Code clones	Tree-based, Text-based		NA, No
[16]	Arcan, Sonargraph, Structure101, CLIO, Designite, DV8, SonarQube, inFusion, AI Reviewer, ARCADE, Hotspot Detector, Massey Architecture Explore, STAN,, SODA	Arcan (Unstable Dependency, Hub-like Dependency, Cyclic Dependency, Multiple Architecture Violations, Specification–implementation Violation), Sonargraph (Unstable Dependency, Hub-like Dependency, Cyclic Dependency, Package Cycles, Biggest Package Cycle Group), Structure101(Unstable Dependency, Hub-like Dependency, Cyclic Dependency, Multiple Architecture Violations, Specification–implementation Violation), CLIO (Modularity Violations), Designite (Unstable Dependency, Cyclic Dependency, Ambiguous Interface, God Component, Feature Concentration, Scattered Functionality, Dense Structure), DV8 (Package Cycles, Unstable Interface, Unhealthy Inheritance Hierarchy, Modularity Violations, Crossing, Clique), SonarQube (Cyclic Dependency), inFusion (Unstable Dependency, Cyclic Dependency, SAP Breaker), AI Reviewer, Hotspot Detector, Massey Architecture Explorer, STAN (Unstable Dependency, Hub-like Dependency, Cyclic Dependency, Implicit Cross-module Dependency, Ambiguous Interface, Cyclic Hierarchy, Multipath Hierarchy, Abstraction without Decoupling, Unutilized Abstraction, God Component, Scattered Functionality, Multiple Architecture Violations), ARCADE (Unstable Dependency, Hub-like Dependency, Cyclic Dependency, Implicit Cross-module Dependency, Ambiguous Interface, Cyclic Hierarchy, Multipath Hierarchy, Abstraction without Decoupling, Unutilized Abstraction, God Component, Scattered Functionality, Multiple Architecture Violations, Unused Interface, Sloppy Delegation, Co-change Coupling, Separation of Concerns, Concern Overload, Link Overload), SODA (Multi-service, Tiny Service, Sand Pile, Chatty Service, Knot Service, Nobody Home, Duplicated Service, Bottleneck Service, Service Chain, Data Service, Bloated Service)	Arcan (Graph-based), Sonargraph (Graph-based), Structure101 (Graph-based), CLIO (Metric-based), Designite (Rule-based), DV8 (Rule-based), SonarQube (Graph-based), inFusion (NA), AI Reviewer (Graph-based), ARCADE (Graph-based), Hotspot Detector (Graph-based), Massey Architecture Explore (NA), STAN (Graph-based), SODA (Rule-based)		Arcan (NA, NA, Java), Sonargraph (NA, NA, (Java, C, C++ C#, Python)), Structure101 (NA, NA, (Java, C++, C, Python)), CLIO (NA, NA, (Java, C++)), Designite (NA, NA, (Java, C#)), DV8 (NA, NA, (Java, C++, C, C#, Python)), SonarQube (NA, NA, (Java, C++, C, C#, Python)), inFusion (NA, NA, NA), AI Reviewer (NA, NA, (C++,C)), ARCADE (NA, NA, Java), Hotspot Detector (NA, NA, NA), Massey Architecture Explore (NA, NA, NA), STAN (NA, NA, Java), SODA (NA, NA, Java)
[25]	NiCad, CPD, iClones	Code clones	NiCad (Text-based), CPD (Token-based), iClones (Token-based, Tree-based)		NiCad (Yes, No, Java), CPD (Yes, No, Java), iClones (Yes, No, Java)
[12]	Smell Detector Merger	Brain Class+, Brain Method+, Class Data+, Should be Private, Complex Class+, Data, Class+, Dispersed Coupling+, Duplicate Code, Feature Envy+, God Class+, Intensive Coupling+, Lazy Class+, Long Method+, Long Parameter List+, Message Chain+, Refused Bequest, Shotgun Surgery+, Spaghetti Code+, Speculative Generality+, Tradition Breaker, Type Checking+	Metric-based, based	Text-	Yes, No, Java
[11]	HBSniff	Eager Fetch, Lacking Join Fetch, One-By-One, Missing ManyToOne, Collection Field. Final Entity, Missing No Argument Constructor, Missing Identifier, Missing Equals Method, Missing hashCode Method, Using Identifier in Equals or hashCode Methods, Not Serializable, Missing Accessor Methods, Local Pagination	Metric-based, based	Tree-	No, No, Java
[20]	ADOCTOR, Paprika (SNIFFER)	NA	ADOCTOR (Rule-based), Paprika (Graph-based, Metric-based)		ADOCTOR (Yes, NA, Java), Paprika (NA, No, Java)

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