Improving Design Smell Detection for Adoption in Industry

Doctoral meeting

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Outline

- Introduction.
- Thesis Proposal.
- State of the Art.
- Thesis plan

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Introduction

- Software quality is one of the main important problems for all software engineers and researchers.
- According to Brown*, a survey of hundreds of software development projects show that five from six projects are considered unsuccessful.
- The majority of software development cost (budget) is devoted to maintaining processes.
- More difficulties in controlling the maintenance process than in other phases of the software development life cycle.
  - Reasons:
    - Complexity of source code.
    - Experience of developers.
    - Amount and frequency of maintenance tasks (Adaptive, Corrective, Perfective).
    - Different tools required. (adapting, correcting, documenting, etc).

Introduction

- Refactoring
  - A set of restructuring operations that support the design and evolution of software but preserving its observable behavior. [Opdyke1992]*
  - A change made to the internal structure of software to make it easier to understand and cheaper to modify without changing it's observable behavior. [Fowler1999]**
  - Identifying pieces of code need to be refactored making the upcoming maintenance tasks easier.
  - Refactoring is a technique used to:
    - Make software easier to modify and increase understandability.
    - Remove design smells (Decrease coupling & Increase cohesive).
    - Improve the design of software.
  - Well known refactoring operations (Extracting class, Extracting method, Move method).

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*[William F. Opdyke. Refactoring Object-oriented Frameworks. PhD thesis, University of Illinois at Urbana-Champaign Champaign, IL, USA, Champaign,IL, USA, 1992. UMI Order No. GAX93-05645.]

**[Martin Fowler, Kent Beck, John Brant, William Opdyke and Don Roberts. *Refactoring: Improving the Design of Existing Code*. Addison Wesley, 1 edition, June 1999.

Introduction

- Design smell
  - Design smells are indicators on weak software design that can potentially decrease software maintainability.
  - Do not produce compile-time or run-time errors.
  - But negatively affect system quality properties, such as understandability, testability, extensibility, reusability and maintainability.
  - These problems can appeared in several software artifacts from fine grained to coarse grained including (variables, instructions, operations, methods, classes, packages, sub systems, layers and their dependencies).

Introduction

- Historical Data
  - Design smells concept cover whole problems related to the software structure (code, design).
  - Design smell appear in the state of the art under different terms:
    - Design heuristics 1996.
    - Antipatterns 1998.
    - Bad smell 1999.
    - Disharmonies 2006.
    - Design flaws 2006.
    - Design defects 2007.
    - Code Anomalies 2007.
    - Design Smell 2011.
  - Different terms used to describe the same type of design smell such as:
    - Large class bad smell (class is trying to do too much).
    - God class disharmony (class performs too much work on its own).
    - Blob antipattern (class with responsibilities that overlap most other parts of the system).

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Introduction

- Design Smell Example (1)
  - Bad Smell (Feature Envy):
    - Occurs when a method in one class uses primarily data and methods from another class to perform its work.
    - **Fix:** (Move Method Refactoring)

      Move the method with feature envy to the class containing the most frequently used methods and data items.

```
public class Phone {
    private final String unformattedNumber;

    public Phone(String unformattedNumber) {
        this.unformattedNumber = unformattedNumber;
    }

    public String getAreaCode() {
        return unformattedNumber.substring(0,3);
    }

    public String getPrefix() {
        return unformattedNumber.substring(3,6);
    }

    public String getNumber() {
        return unformattedNumber.substring(6,10);
    }
}

public class Customer…
    private Phone mobilePhone;

    public String getMobilePhoneNumber() {
        return "(" +
            mobilePhone.getAreaCode() + ") " +
            mobilePhone.getPrefix() + "-" +
            mobilePhone.getNumber();
    }
```

```
public class Phone {
   private final String unformattedNumber;

   public Phone(String unformattedNumber) {
      this.unformattedNumber = unformattedNumber;
   }

   private String getAreaCode() {
      return unformattedNumber.substring(0,3);
   }

   private String getPrefix() {
      return unformattedNumber.substring(3,6);
   }

   private String getNumber() {
      return unformattedNumber.substring(6,10);
   }

   public String toFormattedString() {
      return "(" + getAreaCode() + ") " + getPrefix() + "-" + getNumber();
   }
}

public class Customer…
   private Phone mobilePhone;

   public String getMobilePhoneNumber() {
      return mobilePhone.toFormattedString();
   }
```

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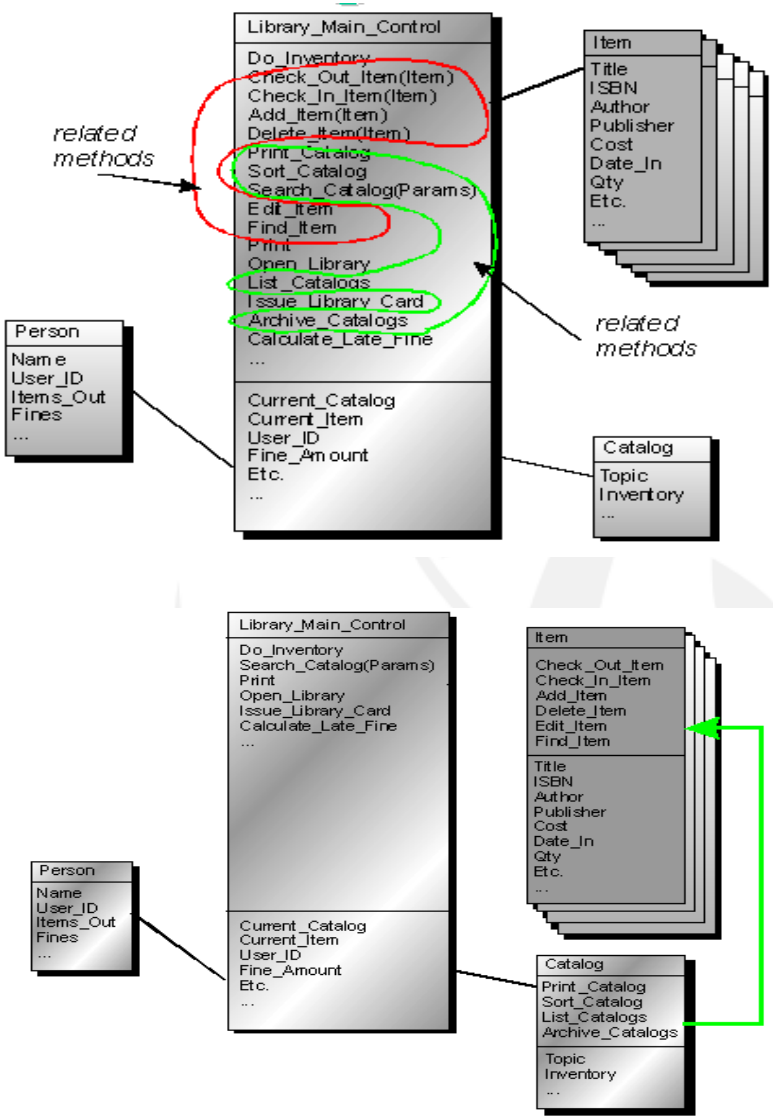
Introduction

- Design Smell Example (2)

  - Architectural Smell (Large Class or God Class or Blob):
    - Occurs when a class is trying to do too much responsibilities or have many methods or instance variables.
    - **Fix:**
    - (Extract Class Refactoring)

      Take a subset of the instance variables and methods and create a new class with them and this makes the initial (long) class shorter.
    - (Move Method Refactoring)

      Move one or more methods to other classes.



Introduction

- **What is the problem?**
  - Design smells detection tools are not widely adopted in industry.
- **Why is it a problem?**
  - Currently software has huge dimensions and Manual detection is not realistic.
  - The available tools can not be identified as useful design smells detection tools that perfectly fits to different software companies/organizations.
- **Why it is an important problem?**
  - Increasing the maintainability time and cost.
  - Negatively impacts on software quality.
  - As a consequence, software lifetime can be shorten.

Thesis Proposal

- Main Goal
  - Improve the usefulness of design smell detection tools for adoption in industry to aid in the increase of software quality and maintainability.

- Sub goals
  - Study in depth the similarities and differences among smell detection techniques to identify the efficiency factors in design smell detection.
  - Organize the knowledge on design smell detection.
  - Analyze the inter-rater agreement between software smell detection tools (automatic experts), human experts and both of them in determining the expected problems in industrial software projects.
  - Make a comparison between techniques to identify the optimal algorithm.
  - Improve the usefulness of algorithm (introduce subjectivity, improve adaptability, gray scale, improve efficiency).
  - Validation in industrial environment .

Thesis Proposal

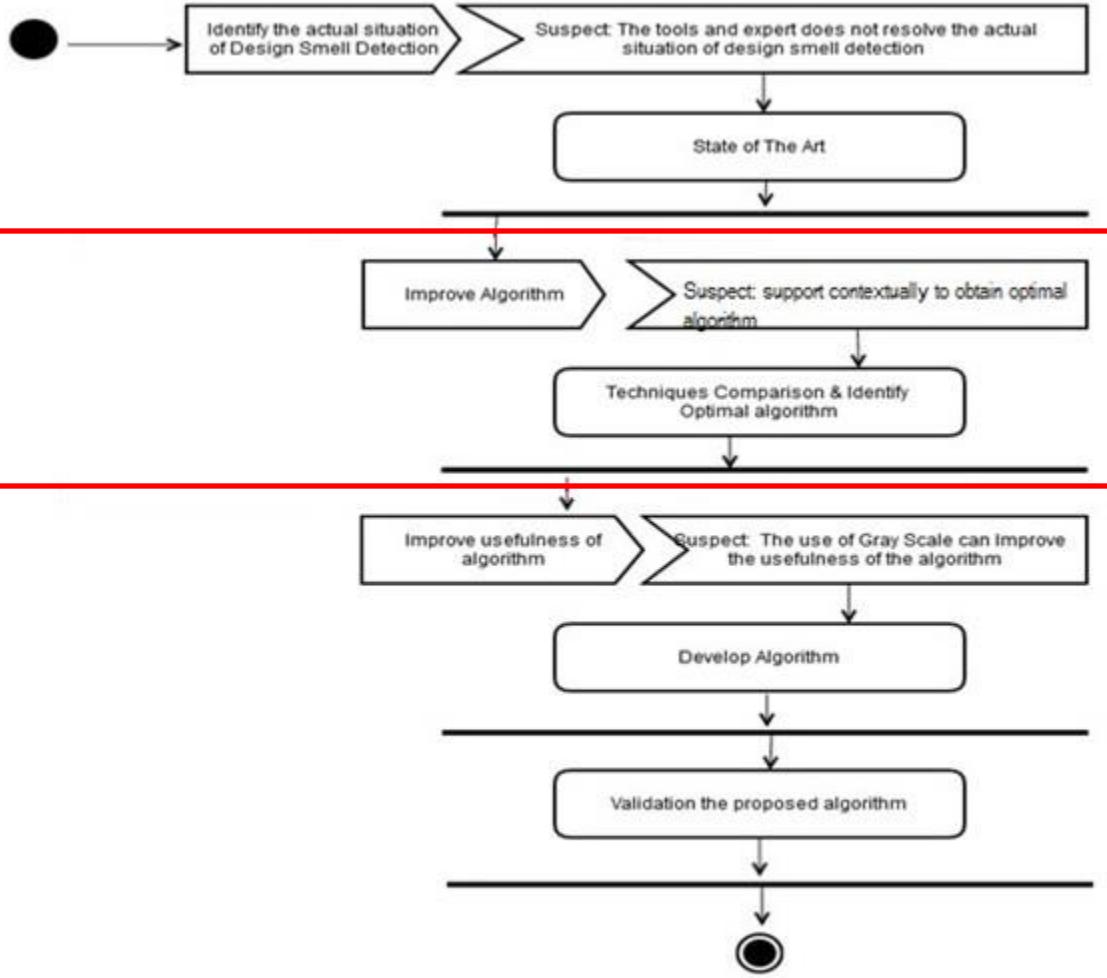
- Activity Diagram

2013/2014

2014/2015

2015/2016

2016/2017



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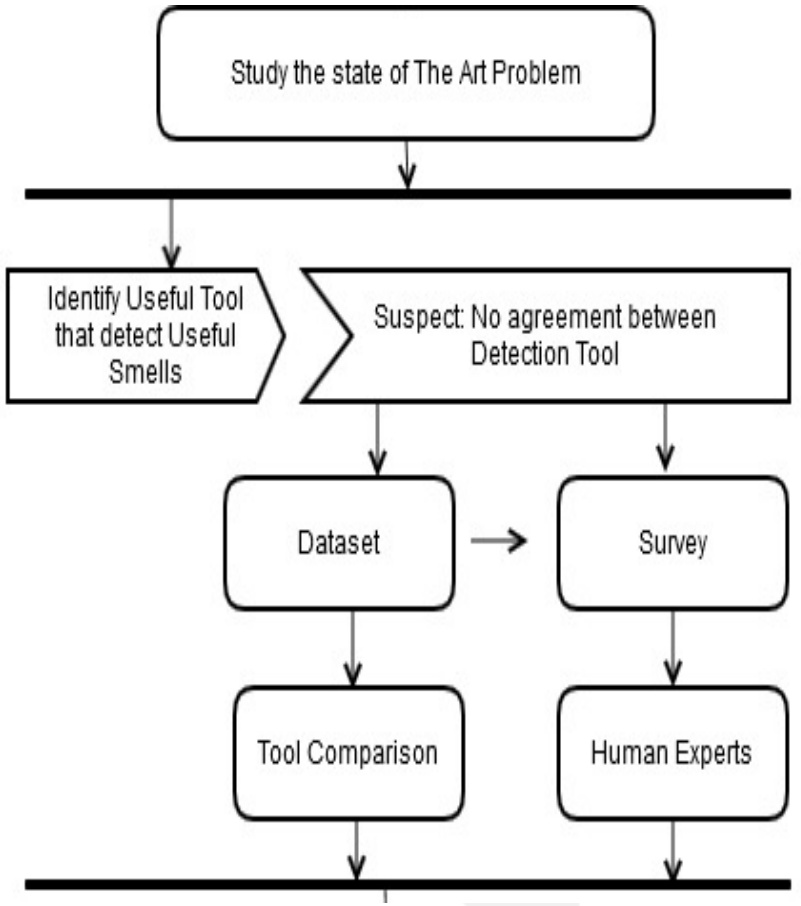
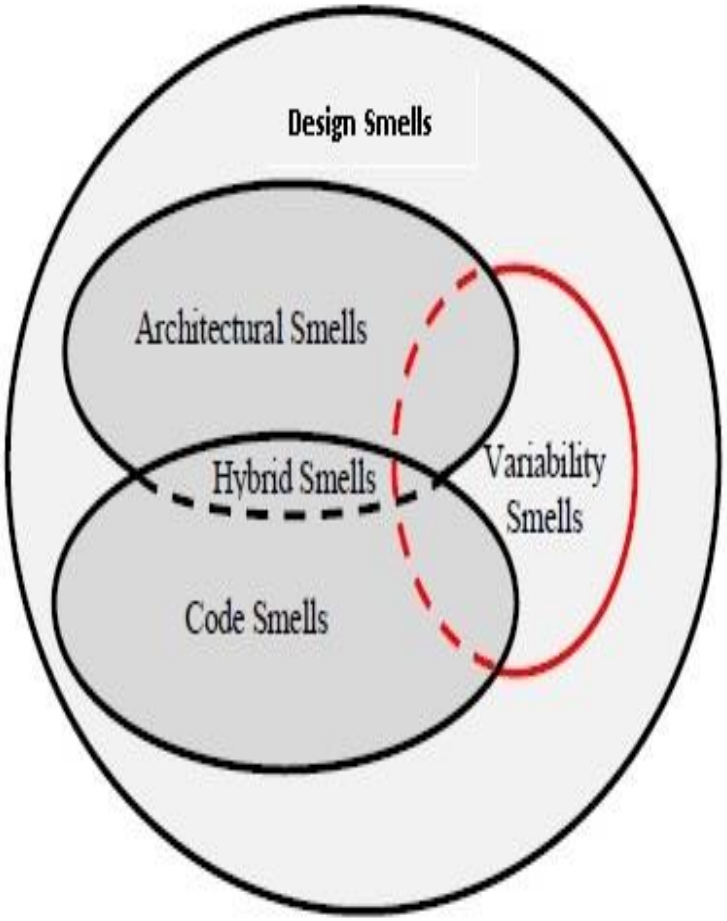
State of the Art

- **State of the Art Activity.**
  - A comprehensive systematic mapping.
    - Identify state of the art problems.
    - Select a set of design smell detection tools.
    - Select a set of design smells.
  - Analyse agreeement in detection
    - Tools comparison.
    - Evaluate the tools on a medium size project.
    - Web-based questionnaire survey.
    - Compute inter-raters agreement between tools, human expert and both of them.

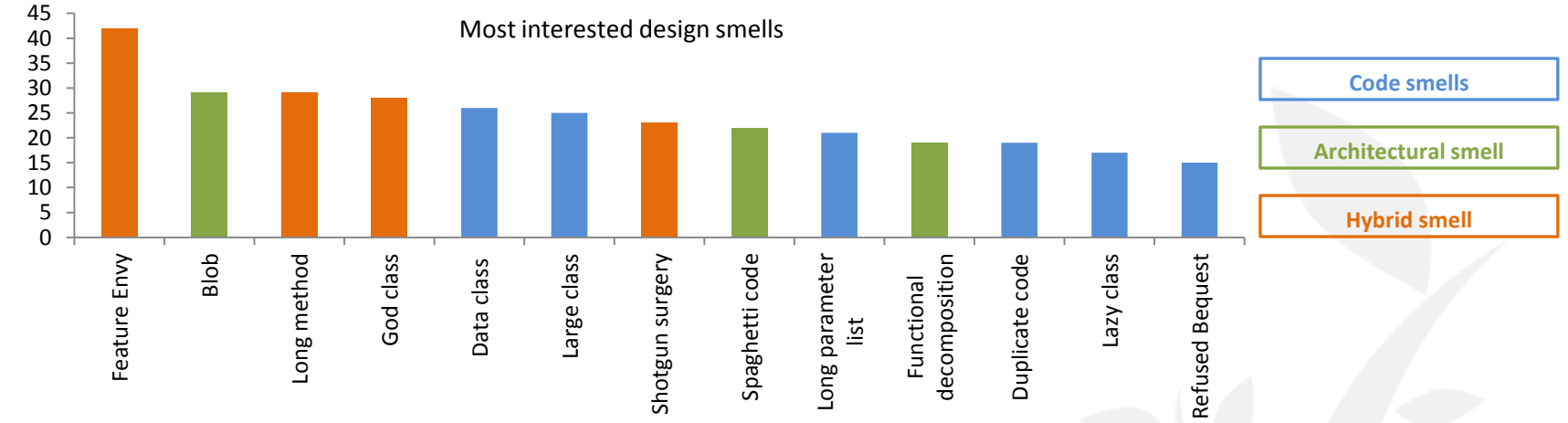


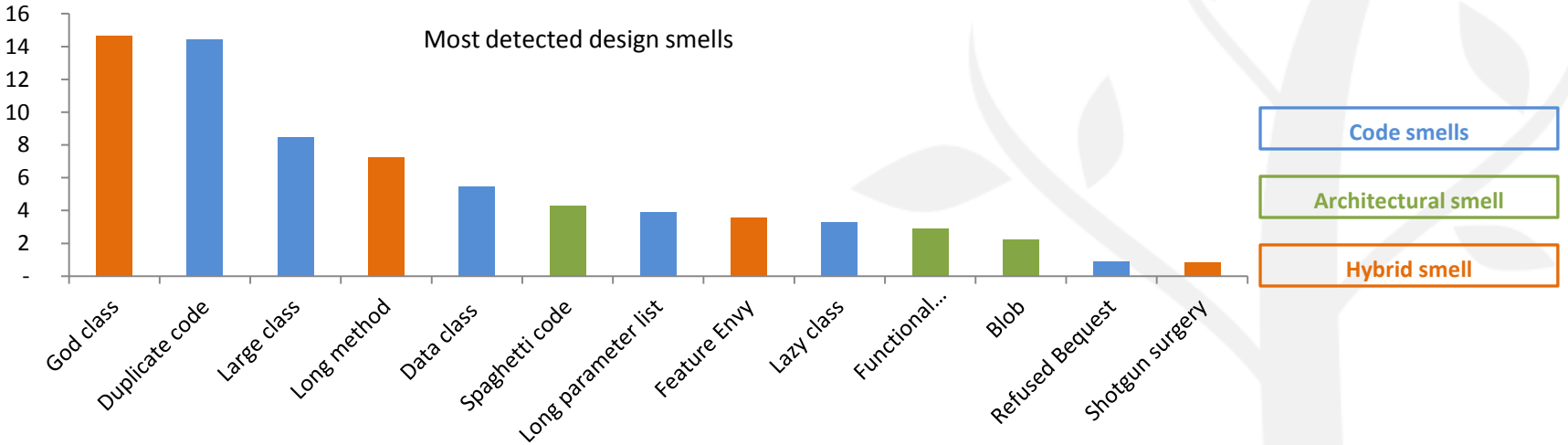
- Different design smell classifications:
  - Bad Smells (Code Smells)
    - Defined in terms of implementation level (subsystem, package, class, fields, methods, parameters and statements).
  - Architectural Smells.
    - Defined in terms of architecture level abstractions (components, connectors and styles).
  - Software Product Line Smells (Variability Smells).
    - Design smells specific to SPLs. They can be divided in parts, such as architectural smells and code smells.
  - Hybrid smells
    - Combine architectural and code smells.



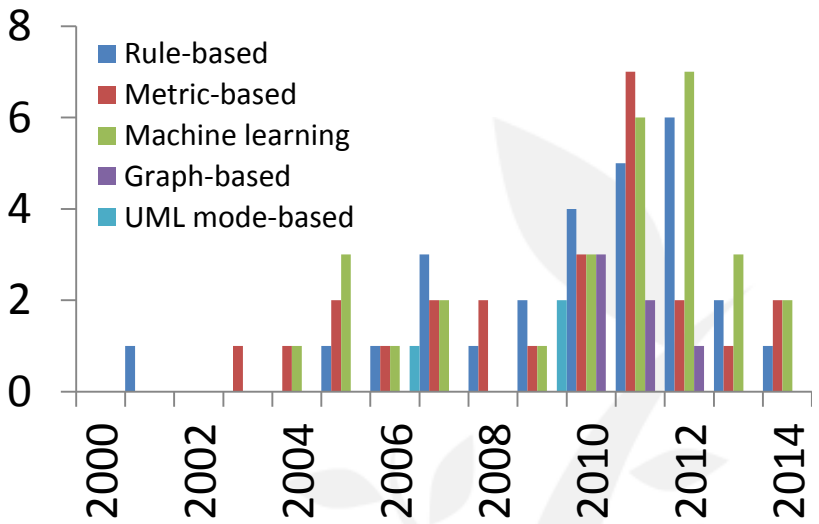
Vale, G. et al., 2014. Bad Smells in Software Product Lines: A Systematic Review. 2014 Eighth Brazilian Symposium on Software Components, Architectures and Reuse, pp.84-94.

- Popular Design smells





- Design Smell Detection Approaches
  - Metric-based approach
    - Detect design smells using existing and new quality metrics by finding relative thresholds values using different techniques and strategies.
  - Rule-based approach
    - Detect smells depending on facts and rules and relation between metrics.
  - Machine learning approach
    - detect smells using learning techniques derived by specific classifiers.
  - Graph-based approach
    - Represent software artifact in vertices and node to extract the important data and to reason on this model.
  - UML approach
    - Use UML meta-model.



Smell/ Approach	Rule-based	Machine learning	Metric-based	Graph-based	UML mode
Feature envy	x	x	x		
Blob	x	x	x		
Large class	x	x	x	x	
Long method	x	x	x		
Spaghetti code	x	x	x	x	
Data class	x	x	x		
Functional decomposition	x	x	x		
God class	x	x	x		
Long parameter list	x		x		
Shotgun surgery	x	x	x		
Duplicate code	x	x	x	x	
Lazy class	x	x	x		x
Other smells	x	x	x	x	x

- Design Smell Tools
  - A few tools deal with:
    - More than one programming languages and Platform.
    - Analyze large size software.
  - Most tools deal with:
    - Limited set of design smells.
    - Mainstream languages(C, C++, Java, C#).
    - Use one input source.
    - Use one representation type.
  - Some of tools generate own metrics to identify design smells and others use metrics generated by other tools.**(Demo)**

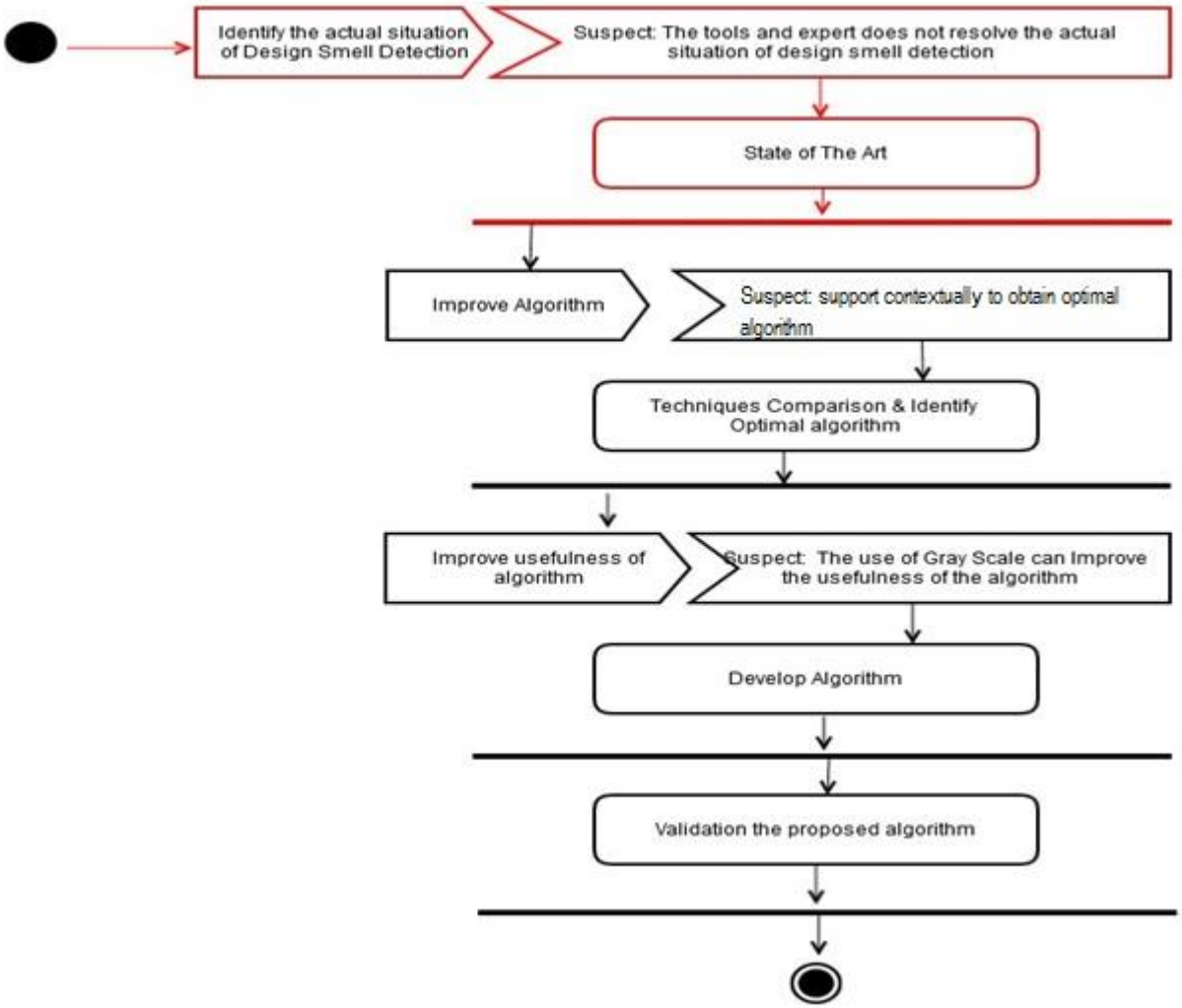
Tool	Design smell	Language	Platform
DECOR	Antipattern + Code smell	Java	Standalone
SourceMiner	Code smell		Eclipse plug-in
Together	Code smell	Java, C++, C#	Standalone
JDeodorant	Bad smell	Java	Eclipse plug-in
PMD	Code smell	Java, C++, C#, C	
		PHP, Ruby, Fortran, PLSQL	Standalone + Eclipse plug-in
iPlasma	Disharmonies	C++, Java	Standalone

Smell /Tool	Decor	SourceMiner	Together	JDeodorant	PMD	iPlasma
Blob	x					
Data class	x		x			x
Duplicate code	x		x		x	
Feature Envy		x	x	x		x
Functional decomposition	x					
God class	x	x	x	x		x
Large class	x	x		x	x	x
Lazy class	x					
Long method	x	x		x	x	x
Long parameter list	x				x	x
Shotgun surgery	x		x			x
Refused Bequest	x					x
Spaghetti code	x					

- Conclusions
  - The attention of researchers community modified from Duplicate code to Feature envy design smells and God class is the most detected design smells in software.
  - Metric-based, Rule-based and Machine learning approaches related with each others and the majority of researchers like to detect smells using them.
  - The most used tools are: JDeodorant, DÉCOR, Together, iPlasma, PMD and SourceMiner.
  - Poor inter-rater agreement between:
    - Design Smell Detection tool.
    - Human experts.
    - Tools and Experts.
  - All detection tools that identify design smell automatically, detect smells as binary decision (having the smell or not).
  - Lack in Empirical studies and Benchmarks availability.

Thesis plan
Improve algorithm

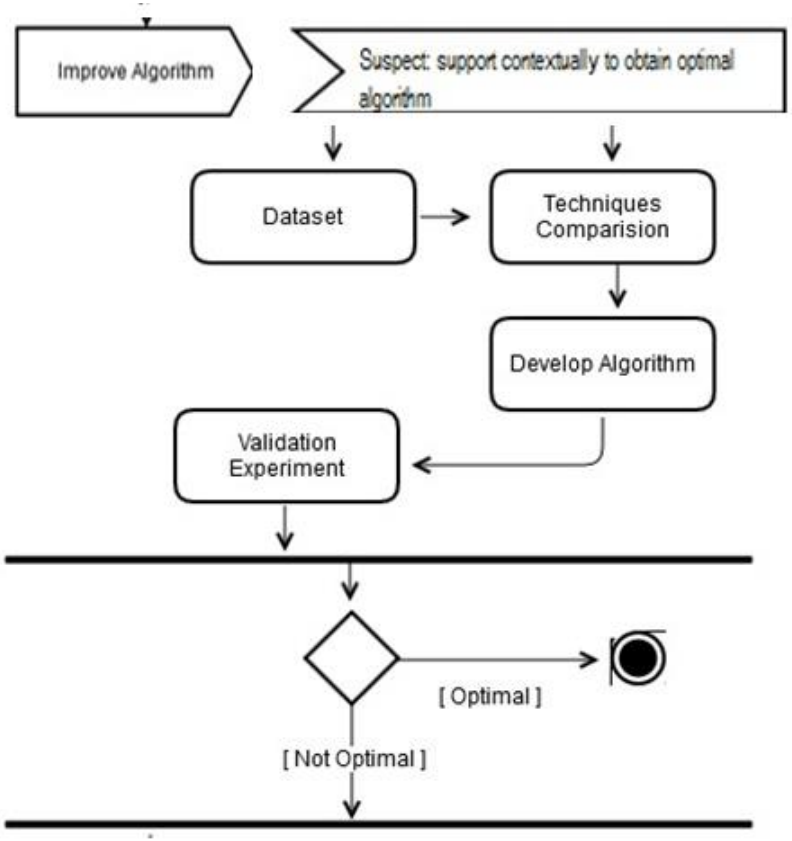
- **Activity Diagram**



Thesis plan

Improve algorithm

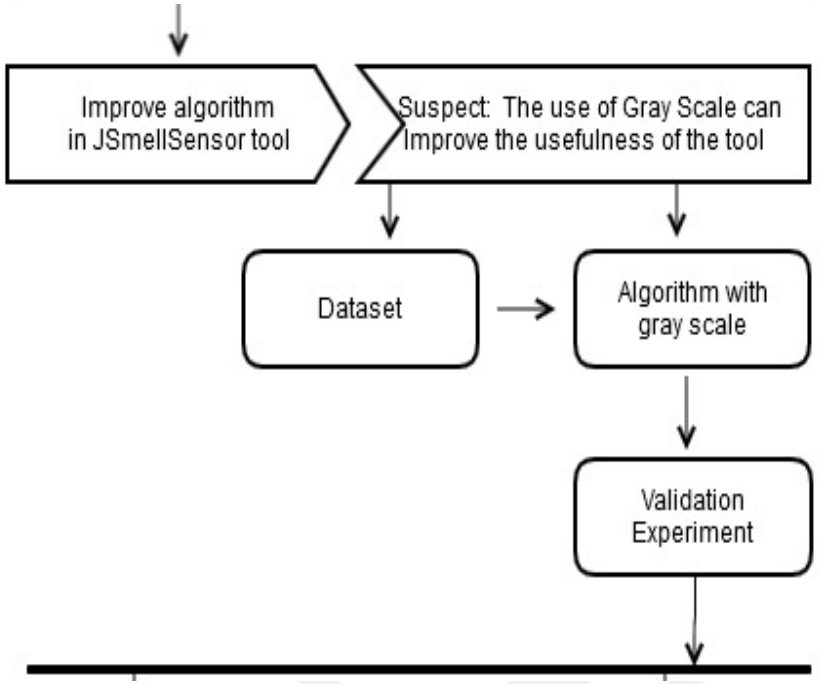
- **Techniques Comparison & Identify Optimal Algorithm Activity.**
  - Preparing a dataset with:
    - Wide set of metrics.
    - Classes classification based on UML stereotypes.
    - Different projects size.
    - Different project domains.
    - Different project status.
  - Make a comparison between different machine learning techniques.
  - Develop improved techniques that are useful for satisfying our goals.
  - Validation experiment on improved techniques.



Thesis plan

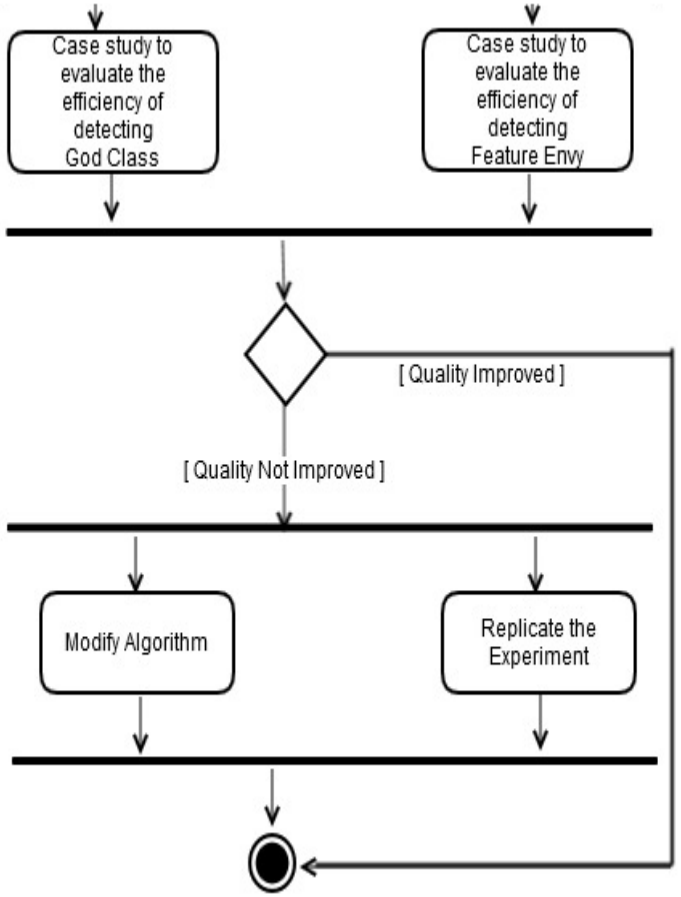
Improve the usefulness

- **Develop Algorithm Activity.**
  - Improve the dataset in Phase three.
  - A gray scale in certain percentage, (God class in class X 70%).
  - Priorities on their impacts on Maintainability.
  - Implement the improved technique with gray scale.
  - Validation experiment on improved algorithm.



Thesis plan
Validation

- **Validation The Proposed Algorithm Activity.**
  - Experiment to evaluate the efficiency of gray scale algorithm on detecting God Class and Feature Envy smells.
  - Produce a report were include:
    - Detected smells with gray scale.
    - Priorities on the highest impact on maintainability.
  - The developer will compare the last report with the actual state of software.
  - Iterative process of modifying the algorithm designed and validation until satisfy the goals.



Thank you for your attention!!!

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