A SYSTEMATIC LITERATURE REVIEW ON MOBILE GAMES DESIGN PATTERNS

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ABSTRACT— *Design patterns are the main building block of any software application. Recovery of mobile games design patterns has many challenges i.e. accuracy and flexibility issues in identifying patterns. The key motivation of this systematic review is to study, analyze and explore state of the art in the field of mobile games design patterns. We apply standard systematic review method with manual search of three digital libraries.56 primary studies are selected by following standard guides for systematic literature review. The quality of the contributions is fair as 56 articles out of 219 are selected as candidate studies after manual peer review. Currently, the solutions presented by different researchers are limited in scope. Many researchers presented different techniques for recovery of Gang of Four design patterns and recovery of mobile games design patterns require attention of researchers.*

Keywords— Reverse Engineering, Design Patterns; Computer games; Games design patterns; SLR

1.INTRODUCTION

Design patterns play a significant for the development of mobile games. Games have become a part of human life. Ludology is a rising research discipline devoted to games and the movement of gaming, which shows the cultural importance of games. The games we are playing are based on a combination of design patterns. Researchers have identified more than 300 patterns in traditional games and computer games [1]. Mobile game design patterns give us a better understanding about games architecture and reuse its code in other environments to develop more games. A position of patterns based on their relevance to mobile games was created together with a set of new games design patterns found especially in mobile games. These two collections of patterns were combined into 74 game design patterns [1]. Recovery is a concept that is used in many domains such as medicine and computing etc. The design patterns explain the recovery concept from architectural level, and give us a clearer understanding of the recovery concept. There are many advantages of recovering design patterns from mobile games i.e. Reusability, Comprehension, Documentation, Reengineering, Maintenance etc. In our domain the recovery of mobile game design patterns is a real challenge. The main challenge in the recovery of mobile game design patterns is large number of variants for implementing the same pattern. Another probable problem is handling implication in patterns. We are still facing problems in integration of multiple search techniques to provide more accurate and effective patterns recovery. Thus we will focus to overcome above mentioned challenges faced by patterns recovery approaches.

The objective of this Systematic Literature Review (SLR) is to analyze and investigate that what type of research is conducted in this field? What are the problems with existing solutions and more specifically what has been the output from the research community in recovering mobile game design patterns? The foremost objective of this systematic review is to inspect the recent research work and present the most significant and motivating input that will help in recovery of mobile game design patterns and might be valuable for the practitioners working in this field. This review also attempts to discover which methods and tools have been applied to recover patterns. The SLR is structured as follows:

We've presented our methodology in the Section 2. Section 3 represents the results and we discuss our results in this section. In the section 4, we discuss limitations of our study and section 5 depicts the conclusions of our systematic literature review.

2.SLR METHODOLOGY

Our systematic literature review on recovery of mobile game design patterns is based on guidelines provided by Kitchenham [6]. It is generally applied research method for gathering requirements for a new research. The SLR research technique gives a generally characterized process for distinguishing, assessing, and translating all accessible proof important to answer research questions [6]. This standard review methodology is selected to answer different research questions.

2.1 Research Questions

The key motivation of this systematic literature review is to gather, analyze and explore existing methods presented for recovery of mobile game design patterns all over the world. We will summarize and use information obtained for recovering mobile game design patterns and build a prototyping tool. This review also attempts to discover which methods and tools have been developed to recover mobile game design patterns. To acquire this objective, we formed a set of research questions to be addressed through this SLR. In process of exploring answers for the research questions, this exploration will highlight the shortcomings of existing research and software systems/tools that have been developed. This will be helpful for us to identify good practices and it will also help to create good techniques for the development of new prototyping tool. The following questions are formulated as a basis for discovering, exploring, and discussing the available literature.

RQ1. *What is the state of the art research on mobile game design patterns since year 2000?*

This question will help us to understand what type of research has been carried out in this area of study in last 14 years. Due to exploratory nature of the study we only included contributions from 2000 and onward, otherwise it will be out

of scope of the study. However we have tried to include most of the contributions since 2000. We reviewed 56 selected papers and categorized contributions into different groups.

RQ2. *What are different lists/catalogs on mobile game design patterns?*

To get an idea of that how many designs patterns are present on mobile games yet. We tried to consider the scope of the study. We want to investigate the current status of different MGDP.

RQ3. *Which methods or techniques have been applied for detection of mobile game design patterns?*

It will help us to find the methods and techniques which researchers used to recover patterns and that will help us in building a new prototyping tool. We target researchers that are currently working in this field.

2.2 Search Strategy:

It is imperative to plan a search strategy for a system literature review. The strategy for our SLR is composed of following steps:

- Create queries to search the databases.
- Choose the digital libraries to get required information.
- Collect and summarize the entire gathered information.
- Create inclusion and exclusion criteria.
- Quality assessment.
- Data Collection.
- Data analysis.

2.2.1 Search Method

Due to time limits and scope of study, we only select three digital libraries for gathering information for the purposed research queries. The whole search process was a manual process to search particular conferences and journal papers since the year 2000.

2.2.2 Search Terms

To find out the most relevant information, main scholar research databases are selected and search queries are designed to search the specific information from database libraries. First query that was created to search the databases was very generic; later on that query was modified to get more precise and relevant results.

2.2.3 Queries

The queries are designed based on our research questions and they are refined in number of iterations. Initially, a generic query was designed to get the results from different databases. Design patterns were the core part of the query because information was useless without focusing on the main part of research.

The first query was: SQ1. "Mobile games AND design patterns OR design principles"

We marked it with "SQ1" (search query 1) for the purpose of keeping record of all research queries. SQ1 query results came up in more than 972 papers

New queries are given below:

ACM Queries:

SQ5: (Title:mobile games) and (Title:design patterns or Title:design principles) Publication Year: 2000 ... 2014

SQ6: (Abstract:mobile games) and (Abstract:design principles)

SQ7: ((Abstract: mobile games) and (Abstract: design patterns or Abstract: design principles)) and (tools or method or techniques or application)

IEEE Xplorer Queries:

SQ8: ((Abstract:"mobile") AND (Abstract:"games") AND (Abstract:"design") AND (Abstract:"patterns")

Refined by: Publisher: IEEE, Content Type: Conference publications, journal and magazines, Publication year: 2000-2014

SQ9: ((Abstract:"mobile games") OR (Abstract:"design patterns") OR (Abstract:"design principles") AND (Abstract:"tools")

Refined by: Publisher: IEEE, Content Type: Conference publications, journal and magazines, Publication year: 2000-2014

SQ10: ((Abstract:"mobile games") OR (Abstract:"design patterns") OR (Abstract:"design principles") AND (Abstract:" tools") AND (Abstract:" applications")

Refined by: Publisher: IEEE, Content Type: Conference publications, journal and magazines, Publication year: 2000-2014

Science Direct Queries:

SQ11: pub-date>1999 and TITLE-ABSTR-KEY(mobile games) and TITLE-ABSTR-KEY (design patterns)[All sources(Computer Science)]

SQ12: pub-date>1999 and TITLE-ABSTR-KEY(mobile games) and TITLE-ABSTR-KEY (design principles) AND LIMIT-TO(topics, "recovery, tools, methods, techniques, applications, computer science")[All sources(Computer Science)]

SQ13: pub-date>1999 and TITLE-ABSTR-KEY(mobile games) and TITLE-ABSTR-KEY (design principles) AND LIMIT-TO(contenttype,"1,2","journal") AND LIMIT-TO(topics, " recovery, tools, methods, techniques, applications, computer science")[All sources(Computer Science)]

Table 1 presents the results from the final queries which were used to search the digital libraries.

Table 1: Statistics of results from search queries

Query	Results from queries	Date
SQ05	214	18-09-2014
SQ06	698	18-09-2014
SQ07	620	19-09-2014
SQ08	123	20-09-2014
SQ09	275	20-09-2014
SQ10	191	21-09-2014
SQ11	2,147	25-09-2014
SQ12	2,193	02-10-2014
SQ13	1,187	02-10-2014

2.3 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria is applied for selecting relevant essential studies to answer the research questions of SLR. Inclusion and exclusion criteria are

boundaries that are used to include relevant studies and filter irrelevant studies which are extracted through search queries. These steps help in selecting the candidate articles from the final results. Inclusion and exclusion should be very clear and straight forward as only those articles should be excluded that meet exclusion criteria and those articles should be included that met the inclusion criteria. The inclusion and exclusion criteria selected for the current review is as following:

2.3.1 Exclusion Criteria

- Articles not related to mobile games or design patterns.
- Articles not written in English.
- Articles not related to recovery of design patterns and mobile game design patterns.
- Articles published before 2000.

After applying the queries in particular databases; a set of papers were selected and all the selected papers were listed in an excel sheet. After listing all the articles, abstract of each contribution was reviewed and then marked as included or excluded, as reading the abstract provide enough information whether the article meets the exclusion criteria or not. Articles that meet the exclusion criteria were then removed from the list. Articles [57,58] were excluded from the final list on the basis of criteria discussed above.

2.3.2 Inclusion Criteria

- An article that provide a theoretical solution for recovery of MGDP.
- An article that reports tool and method which could be used for development of prototyping tool.
- An article that provides a list/catalog of MGDP.

Articles that meet at least one inclusion criteria are included in the list for gathering information. An inclusion criterion was applied to all the articles that were output of the exclusion criteria. After reading abstract of all papers and applying the inclusion criteria, short listed articles were categorized in a separate list.

2.4 Study Selection

56 primary studies are selected for this SLR which are given in the reference section. In the querying stage, we have got 1093 papers from the three digital libraries. As in the first stage a large number of papers were selected by reading the title, abstracts, and keywords. There were some papers that were left for the next stage because these papers can't be judged to include or exclude by reading the titles, abstracts and keywords. To find out more precise results we applied the exclusion criteria to filter papers that did not match out requirements. Out of 1093 papers, 416 papers meet our requirements so these papers were selected for the next stage.

In the final stage, we applied the inclusion criteria on papers that were selected by applying the exclusion criteria. We selected 219 relevant papers by applying the inclusion criteria. We applied the criteria by reading the titles, abstracts, keywords and conclusions of the papers.

Final papers which are selected after applying both criteria's were again checked by the two authors and any differences were resolved. All papers are selected by going through the three stages. The papers about which decision was not made either to include or exclude were retained for the next stage and similarly some papers were also retained at the second stage

2.5 Quality Assessment

A quality assessment criterion was defined to assess quality of the current study. We have included papers that are published in top journals and conferences, and workshops that are held in software engineering. Criteria to assess the quality are based on the following questions:

- Are review's exclusion and inclusion described and appropriate?
- Is the searched literature covered all important studies?
- Did the reviewer's assess the quality of included studies?
- The questions of quality assessment section answered as follow:

QA1. Yes the criterion for exclusion and inclusion was defined according to search questions. Inclusion and exclusion criteria helped to find out the relevant and appropriate information for large data set.

QA2. The scope of systematic review conducted for this study is based on data primarily extracted through three well known digital libraries. Authors of review cover all studies published in these three digital libraries. It is possible that they might miss studies on this topic which are not published by these three libraries.

QA3. Yes they have defined the quality criteria for inclusion of the primary extracted data. They assessed the quality of studies by using the DARE criteria. Points are given to each article according to its contributions in the research questions. Every article that got at least 8 is selected and all other articles are rejected.

2.6 Data Collection

In the data collection phase, we closely inspect the existing contributions on the recovery of MGDP. We have collected a set of parameters that describe each primary study. For every study, we extracted the following data:

[X1] Year of publication
[X2] Publication Venue (journal, conference, workshop)
[X3] Research Focus (catalog/list of MGDP, definitions, Detection and specification of MGDP)
[X4] Tools/Techniques
[X5] Source Code
[X6] Published in (journal or conference)

To accomplish this task, first of all queries were developed to find out relevant information from different digital libraries. We dig out all the appropriate information required to answer the research questions by applying inclusion and exclusion criteria. After applying both criteria, irrelevant information was excluded and only specific information was selected.

We have extracted the data and resolved its conflict. The extracted data was then checked for consistency. By applying the inclusion and exclusion criteria we got 219 studies. To get more relevant studies, we then use the DARE criteria which helped us to find out more precise and relevant results.

DARE criteria is based on five categories and each category is assigned 4 points. The articles that scores at least 8 points from all five categories are selected as most relevant contributions. After this step, 56 contributions were selected for further analysis.

Finally, we further classify these selected contributions into Research Focus, publication venue, pattern scope, tools/techniques and source code.

2.7 Data Analysis

This section explains how the results extracted from the data collection are analyzed. To answer all the research questions, it is very important to include information from all aspects in the extraction sheet.

3. Results and Discussion

This part describes the findings from the literature review. Figure 3 shows the output of different phases of the examination of literature.

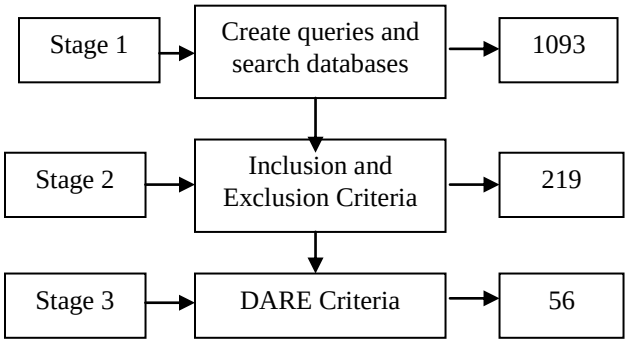

Fig 3: Stages of review methodology

3.1. Search Results

We identified 219 unique studies through our research process. These short listed articles are selected after applying the inclusion and exclusion criteria.

We classify the contributions in five attributes. First attribute 'Research Focus' describes whether the paper is on list/catalog of game design patterns or specification/visualization/ definitions of design patterns. Second attribute presents 'Pattern scope' represent whether the article is related to gang of four DP or mobile game design pattern. Third attribute 'Publication venue' illustrates whether it is a case study or workshop or a survey paper. Fourth attribute 'Tools/Techniques' presents different prototyping tools and techniques which researchers used in detection of DPs. Fifth attribute 'Source code' describes which type of source code is used by researcher in recovering design patterns i.e. java, C++ etc.

3.1.1 Research Focus

It tells us what the aims of current study are. Research focus includes whether the paper is related to:

- List/catalog of mobile game design pattern
- Definitions, specification or visualization of Mobile game design patterns.
- Detection of design patterns

3.1.2 Publication Venue

It tells whether it is a survey paper, case study or workshop paper

3.1.3 Pattern Scope

Pattern scope is an attribute which shows that the understudy paper/article is associated with gang of four design patterns or mobile game design patterns or DPs and gives us a clearer picture and understanding of that idea.

3.1.4 Tools/techniques

In this attribute we will see different tools and techniques which researchers follow in recovering design patterns that will help us in making our prototyping tool more efficient.

3.1.5 Source Code

Basically it tells us what source code researchers used in recovering design patterns i.e. java, C++, c sharp etc.

The above studies are very helpful because we can sort our following issues:

- What are current recovering issues?
- Problems of recovering MGDP.
- Ideas that can help for recovering MGDP.

56 studies are selected for data extraction and to find out the answers of research questions. These studies are organized in the five categories as described in the 'Result' section. In this section we discuss the answers to our research questions.

RQ1 What is the state of the art research on mobile game design patterns since year 2000?

In the first research question, we have discussed that what type of research has been done in this area of research. Hence we have divided our study in five attributes and after applying the By applying, DARE criteria we identified and then finalized 56 studies. These 56 studies are divided into five categories, which are mentioned below:

1) Research Focus
2) Publication Venue
3) Pattern Scope
4) Tools/Techniques
5) Source Code

Table 2 shows the number of contributions in each year since 2000. (Table only contains contributions that are chosen by DARE criteria).

Out of 56 studies that have been selected using the DARE criteria, some studies represent what is 'research focus' of the paper either it is on list/catalog of game design patterns or specification/visualization/ definitions of design patterns, some studies shows what is the 'pattern scope' whether it is on gang of four design pattern or mobile game design pattern and some shows 'publication venue' which tells whether it is a survey paper, case study or workshop paper, some studies present the 'Tools/Techniques' that was applied for detection of design patterns and 'Source code' which shows whether the researchers took java or C++ code for pattern detection in this area of research since year 2000.

RQ2. What are different lists/catalogs on mobile game design patterns?

There are different design patterns in mobile games; at first we categorize the studies into five categories but later on, to

Table 2 :Contributions per year

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Number of studies	3	2	3	2	0	2	1	2	2	3	8	7	8	13

get into more detail of finalized studies we discovered 7 types of MGDP and categorized them according to their specific type as shown in Table 3.

Table 3: MGDP papers and their categories.

Serial #	Type of research paper	Number of references
1	Identification of game design patterns, case studies	[1] [56] [58]
2	Game design patterns and elements	[25] [26]
3	List/catalog on game design patterns	[1] [3] [4] [10] [21] [44] [45] [56]
4	Specification on game design patterns	[42] [43] [40] [34 [8] [22]
5	Game design patterns, framework	[24] [27]
6	Definitions of game design patterns	[21] [27] [28]
7	Visualization on game design patterns	[6] [9] [37] [41]

Papers [1,10, 56] are related to game design patterns. These provide a catalog/list of game design patterns with different case studies. This helps to finalize common occurring game design patterns and use those patterns and recover them by using prototyping tool.

6 papers [13,14,15,18,1920] provide solutions for detection of design patterns with different tools/techniques. These studies use case studies and experiments to recover design patterns. Authors of the paper [23] recovered design patterns by using static and dynamic analysis in case study.

After analyzing and examining available data we realize that MGDP is a wide and open research area. There is an increasing interest in the MGDP field and there has been a considerable support for recovering MGDP in major conferences. Developers are developing solutions for the recovery of MGDP and will continue to do so in the coming years. It is also importance that the developed prototype tool could be used at different levels to fulfill the requirement of all researchers.

RQ3. Which methods or techniques have been applied for detection of mobile game design patterns?

Numbers of researchers are working on mobile game design patterns and its recovery. Mobile game design patterns are still inventing according to different game types. Researchers used many tools and techniques in recovery of mobile game design patterns. After applying the Dare criteria the above study shows many tools/techniques that are being accessed by researchers for effective pattern recovery. 33 studies show tools/Techniques for recovery of design patterns.

The main problem with the available tools is that majority of tools show fine results but accuracy and precision issue is still there that is not solved yet. Some researchers have given ideas, methods and techniques in recovering design patterns [40,41,42]. Such studies are important for gathering information about recovery of design patterns.

Many papers [47,48,49,50,51,52] provide solutions for the recovery of design patterns. These solutions include various methods and tools i.e. graph technique, spin model tool, DPD tool, micro-structure techniques, ePAD tool etc. One paper uses graph isomorphism technique with matrix and algorithms for detection of design patterns [55]. A matrix based approach to recover design patterns with DP-miner tool is used in [29]

Although a lot has been done in this field but still we cannot find any complete solution that is handling accuracy issue in recovery of design patterns. Improvement of existing tools and methods and addition of new tools is valuable.

4. Limitations of study

Our study deviated from the Kitchenman's guidelines [6] in some ways. Following are the points:

- Limited number of digital libraries
- Candidate studies are selected by only by two researchers
- DARE criteria

Only three digital libraries IEEE Explorer, Science Direct, ACM digital Library are selected for data extraction. Because of the time limits and scope of the study only these three libraries are selected. So there are chances that we have missed the articles published in some journals and conferences, which can address the research question more precisely. Thus our result must be qualified as applying to only those articles which are available in above motioned three digital libraries.

Second point state that all the studies are selected by two researchers for review. There might be a chance of missing some articles that can prove very helpful. However, articles that are selected as candidate are reviewed by other researchers at the time of applying inclusion and exclusion criteria and conflicts were resolved before applying DARE criteria.

Third point is DARE criteria. We developed our own DARE criteria according to nature of research questions. Researchers might raise questions about the selection of articles.

5. CONCLUSIONS

The motivation for this systematic literature review is to explore state of the art in the area of mobile game design patterns. The main purpose of this systematic review is to find out the current research contributions and search valuable contributions, issues that can help out in recovering mobile game design pattern. Our systematic literature review also attempts to find out which methods and tools have been developed for recovering mobile game design patterns.

Our Systematic literature review is based on 56 primary studies. According to nature of our study, we categorized these 56 studies into five attributes. One represents the research focus whether it is associated with list/catalog of mobile game design patterns or definitions, specification and visualization of design patterns [1, 44, 45, 56]. Second attribute shows pattern scope whether the paper is related to game design patterns or gang of four design patterns [11, 24]. Third attribute publication venue shows that it is a case study for detection of MGDP or workshop for identifying new patterns or a survey [1]. Fourth attribute shows category of Tools/Techniques which researchers used in recovering MGDP [14, 15]. Fifth attribute shows input language for recovering design pattern i.e. java source code or C++ [18, 19 ,20].

In our systematic literature review, we explored various papers on identification of game design patterns [1, 56, 58]. There are also papers that describe catalogs on game design patterns [21, 44, 45, 56]. Many papers are also on specification, definitions and detection of game design patterns. Various tools and techniques are applied on detection of design patterns but we have not found any techniques on detection of game design patterns that's a major research gap in it. We found lots of game design patterns their definitions, description and examples. Many papers show specification of game design patterns in many game plays. Some papers develop games and found relationships between design patterns and identify new game design patterns.

From our systematic literature review, we conclude that most attempts are being done on the detection of gang of four design patterns but no work is done on detection of mobile game design patterns that's a major research gap. Various tools and techniques are used for recovering gang of four design patterns but no techniques are found on recovery of mobile game design patterns. One of the key problems with most works is their accuracy and flexibility issue in effective pattern recovery of design patterns. This is a main limitation in recovery of gang of four design patterns and same for the mobile game design patterns. This provides future challenges to overcome accuracy and flexibility issues in pattern recovery.

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