Concepts and Modelling Techniques for Pervasive and Social Games

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Agenda

• Introduction
  – Problem Statement
  – Research Questions and Challenges
  – Research Contributions
  – Research method

• RC1: TeMPS
  – Introduction
  – State of art
  – Evaluation

• RC2: PerGO
  – Introduction
  – State of art
  – Evaluation

• RC3: GCCT
  – Introduction
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  – Evaluation

• Conclusion and Future work
  – Research Method
  – TeMPS
  – PerGO
  – GCCT
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Problem Statement

• Pervasive Game vs. Computer Game
• Features
  – Location-based
  – Physical user interfaces
  – Mobile devices
  – ...

[Images of people playing games in various locations]
Problem Statement

- Game Development Tools
  - Authoring tools
  - Engine tools
  - Customized authoring tools?

Tailored features
- Unnecessary learning
- Easy user interface to edit
- Full code generation

Problems 😞
- No tools for your games?
- Does not meet all requirements?
- Complex to learn?
Problem Statement

• Model Driven Software Development (MDD)
  – Model as the primary artifact
  – Domain Specific Language (DSL), Domain Specific Modelling (DSM)
  – Code automation
• MDD for games
  – to implement customized tools?
    • conceptual challenges (base of reusing game domain knowledge in MDD)
    • procedural challenges (how to reuse domain knowledge and respect game development traditions in MDD)
Research Questions and Challenges

- **RQ1:** What important concepts need to be considered regarding creating pervasive games with a model driven approach?
  - **RQ1.1:** What important characteristics should/may a pervasive game have?
  - **RQ1.2:** What concepts can be used in a Domain Specific Language (DSL) of pervasive games?

- **RQ2:** How can MDSD techniques be applied in a traditional pervasive/computer game creation process?
  - **RQ2.1:** How can a formalized domain vocabulary be used to enhance the domain analysis process in order to create pervasive games with a DSM approach?
  - **RQ2.2:** How can a traditional computer game development process be adapted to support DSM tasks in an efficient and iterative way?

- Lack of common **vocabularies** shared between computer (and pervasive) games for the purpose of applying MDSD (C1)
- Lack of a consolidated **definition** of pervasive game (C2)
- Lack of a **structured domain analysis process** to reuse domain knowledge efficiently (C3)
- Lack of consideration of computer game traditions when applying the MDSD process (C4)
Research Contributions

- **RC1**: A conceptual framework named *TeMPS* (meaning Temporality, Mobility, Perceptibility and Sociality) to summarize important characteristics of pervasive and social games.
- **RC2**: An ontology named *PerGO* (meaning Pervasive Game Ontology) to structure and accelerate domain analysis for model driven pervasive games development.
- **RC3**: A process named *GCCT* (meaning Game Creation with Customized Tools) to make use of model driven techniques within the traditional computer game development process.

<table>
<thead>
<tr>
<th></th>
<th>RQ1.1</th>
<th>RQ1.2</th>
<th>RQ2.1</th>
<th>RQ2.2</th>
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</thead>
<tbody>
<tr>
<td>RC1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RC2</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>RC3</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Research Methods

• Two paradigms in IS research:
  – *behavioural science* – “*truth*”
    • develops and verifies theories that explain or predict human behaviour or organization
  – *design science* – “*utility*”
    • improve or extend the capacities of man or organization by building new artefacts

• Design is both a process (activities) and a product (artefacts).

<table>
<thead>
<tr>
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TeMPS

- a conceptual framework for characterizing pervasive games
- provides an approach to better understand
  - what are pervasive games and
  - what features we should consider when trying to develop such games
- serves as a base for the other research contributions of this thesis
TeMPS

- Temporality
  - addressing the game’s temporal property,
  - i.e. whether the game is played in a fixed time/round or not (open beginning and/or open ended);

- Mobility
  - addressing the spatial property,
  - i.e. whether the game could be played anywhere or whether it is fixed in one place;

- Perceptibility
  - addressing how the game is mixed with reality,
  - e.g. does the game construct the appearance of the player proxy in the game by sensing the player’s real world appearance? Does the player need to physically move to move virtually in the game?; And finally,

- Sociality
  - addressing the player’s relationship with and social influence of the game.
# TeMPS: Evaluation

![Table of Pervasive Games Reviewed by the TeMPS Framework](image_url)

*Figure 68. Pervasive Games Reviewed by the TeMPS Framework*
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Pervasive Game Ontology (PerGO)

- PerGO includes:
  - A Domain Vocabulary
  - A Domain Analysis Procedure

- PerGO is based on
  - an understanding of pervasive games (through TeMPS) and
  - general requirements from model driven techniques

- PerGO is the basis of the domain analysis part in the GCCT approach.

The expected progression from domain knowledge to DSL models.

- Firstly, an ontology (PerGO) is used to formalize the common domain knowledge for pervasive games.
- Then DSL meta-models are constructed by customizing the ontology for the more specific domains like pervasive treasure hunting games.
- When the DSL is ready to use, it will be possible to write specifications (DSL model) using the DSL. Such specifications are instances of the corresponding domain model (DSL meta-model) and can be used to generate game software by utilizing MDSD tools.
PerGO: Structure

- In total more than 100 concepts
- Concepts are organized into 6 perspectives which focus separately on different aspects of game software.
- Two levels of concepts:
  - high-level concepts which are common to all computer games and
  - low-level concepts which are specific to pervasive games (primarily used or often used by pervasive games)
  - low-level concepts are derived from the high-level concepts
PerGO: Core Part and Pervasive Part

- Perspectives:
  - Gameplay perspective
  - Artificial Intelligence (AI) perspective
  - GameWorldElement
  - Control
  - Presentation
  - CtrlPresentation
PerGO: DA Procedure

The four steps proposed are:

1) Quickly identify perspectives that are related to the current domain, and record them in the first column;

2) Go through the perspectives in the first column. For each one, consider the corresponding common game design, then select useful concepts from PerGO or derive more specific concepts for the domain based on PerGO to represent this design. Record the concepts in the second column, in case there is more detailed information, especially attributes corresponding to the concepts, and record them in the third column;

3) Similarly to step 2), go through the perspectives in the first column. This time, consider the variable game design that may be used in different game samples. Decide whether some other concepts (within PerGO or newly invented) are needed besides those that have been listed in the second column, and add them if this is the case;

4) Go through all of the concepts in the second column, and decide how to utilize attributes of them or relationships among them to support the variable game design. Then write them in the last column.

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Concept</th>
<th>Commonality Details</th>
<th>Variability Details</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## PerGO: Related Work

<table>
<thead>
<tr>
<th></th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Formal DA Methods</strong></td>
<td></td>
</tr>
<tr>
<td>Structured DA/DD</td>
<td>* s s s</td>
</tr>
<tr>
<td>Pre-defined Vocabulary</td>
<td>* s</td>
</tr>
<tr>
<td>Full-spectrum Vocabulary</td>
<td>* *</td>
</tr>
<tr>
<td>DSL (Not GPL)</td>
<td>* * * * * * * *</td>
</tr>
</tbody>
</table>

PerGO: Evaluation

- **(Effectiveness)** The vocabulary should support the implementation of the domain specific features;
- **(Effectiveness)** The concepts within the vocabulary should be constructive and of proper abstraction level and complexity to support the implementation of DSM artefacts;
- **(Efficiency)** The domain analysis process should be reasonably ordered to solve the design dependencies/ constraints
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GCCT

- Game Creation with Customized Tools
  - create tools according to specific domain requirements, then
  - create games with these tools
- GCCT utilizes PerGO for the domain analysis part
GCCT
## GCCT is Based on MDD

<table>
<thead>
<tr>
<th>GCCT tasks</th>
<th>Corresponding MDD tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tools Customization</strong></td>
<td>1. 1 Domain analysis according to project requirements</td>
</tr>
<tr>
<td></td>
<td>1.2 DSL meta-model/ abstract syntax definition based on domain analysis results</td>
</tr>
<tr>
<td>1. Game feature Customization</td>
<td>2. 1 Style selection according to project requirements</td>
</tr>
<tr>
<td></td>
<td>2.2 DSL concrete syntax definition based on the DSL meta-model and the editor style</td>
</tr>
<tr>
<td>2. Game Editor Customization</td>
<td>3. 1 Code template definition based on the DSL meta-model and codes of a working prototype</td>
</tr>
<tr>
<td>3. Game Code Generator Customiza</td>
<td>4. 1 Model creation based on the DSL</td>
</tr>
<tr>
<td>4. Game Creation</td>
<td>4.2 Code generation according to the model</td>
</tr>
</tbody>
</table>
GCCT is an Enhanced MDD Approach

- MDD has drawbacks:
  - Non-trivial (upfront and continuous) cost for tool development
  - High technical threshold
  - Resistance from the team due to such reasons

- Enhancements in GCCT to alleviate some drawbacks:
  - Structure existing game tasks/documents to produce domain analysis outputs
  - Accelerate the domain analysis based on predefined domain vocabularies
  - Reuse existing working prototypes to construct code generators
  - Utilize the state of the art and highly integrated language workbench tools
## GCCT: Related Work

<table>
<thead>
<tr>
<th>Domain Analysis Approach</th>
<th>Adapted Process</th>
<th>Real Cost Data</th>
<th>Cost Structure Analysis</th>
<th>Usage Scenario (When)</th>
<th>Efficiency Tips (How)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Furtado and Santos 2006, Furtado, Santos et al. 2010)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
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<tr>
<td>(Tang, Hanneghan et al. 2008)</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>(Reyno and Cubel 2008, Reyno and Carci Cubel 2009)</td>
<td>-</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
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<tr>
<td>(Walter and Masuch 2011)</td>
<td>-</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>(Maier and Volk 2008)</td>
<td>-</td>
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<tr>
<td>(Moreno-Ger, Sierra et al. 2007)</td>
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<td>Y</td>
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<td>-</td>
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<tr>
<td>(Hernandez and Ortega 2010)</td>
<td>Y</td>
<td>-</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>(Zhang 2005)</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>(Funk and Rauterberg 2012)</td>
<td>-</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>GCCT</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
GCCT: Evaluation

Cost
- Empirical data
- Cost structure
- Practical lessons

<table>
<thead>
<tr>
<th></th>
<th>RealCoins</th>
<th>RealPacman</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCS (Manual)</td>
<td>14</td>
<td>8.267</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>GC CT Tools</td>
<td>11</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>78.6%</td>
<td>64.1%</td>
</tr>
<tr>
<td>Game</td>
<td>0.75</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>5.4%</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>RealCoins</th>
<th>RealPacman</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCS (Manual)</td>
<td>1263</td>
<td>363</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>GC CT Tools</td>
<td>255</td>
<td>167</td>
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<tr>
<td></td>
<td>20.1%</td>
<td>46.0%</td>
</tr>
<tr>
<td>Game</td>
<td>59</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>4.67%</td>
<td>25.6%</td>
</tr>
</tbody>
</table>
# GCCT: Evaluation

![Diagram showing GCCT, GCEE, and GCAT with customizability and maturity of tools on axes]

## Table 10: Choosing from Game Creation Approaches: GCAT, GCEE, GCCT and GCS

<table>
<thead>
<tr>
<th>Attributes</th>
<th>GCAT</th>
<th>GCEE</th>
<th>GCCT</th>
<th>GCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using ready-made tools</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Modifying tools and use</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Creating tools and use</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Not using tools</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Small upfront efforts</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Low technical threshold</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>2. Game design</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>3. Programming</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>4. Language engineering</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>5. Quick start (Fit for small samples)</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>6. Accumulated benefits on large samples</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>7. Formality of game specification</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>8. Formality of tool specification</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>-</td>
</tr>
<tr>
<td>9. Formality of tool development process</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>-</td>
</tr>
<tr>
<td>10. Tool customizability</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>11. Small learn/use burden for unnecessary features</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>12. Low dependence on 3rd tools</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>
GCCT (&PerGO) Evaluation: User Acceptance

- RQ1: Will PerGO and GCCT be accepted by potential users?
  - MDD has drawbacks: cost, technical threshold…
  - Persons are often resistant to use MDD due to such drawbacks
  - GCCT enhanced MDD in game domain

- RQ2: Will game and MDD background hinder the user acceptance of PerGO and GCCT?
46 responded to the survey

**Result:**
- Both PerGO and GCCT were perceived to be useful, easy to use, and might be adopted by most of the respondents.
- People with some pervasive game knowledge might find PerGO to be more useful and more easy to use.
- Knowledge of general computer game development and MDD expertise did not obviously influence the usefulness and the ease of use of PerGO or GCCT.
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# Evaluation: Research Method

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Limitation and Future Work: TeMPS

- The four dimensions defined in TeMPS are quite uneven.
- The suggested set of perspectives or their options/aspects is not exhaustive.
- TeMPS does not specify which features are mandatory or optional for a pervasive game.
- TeMPS is somewhat empirical and lacks solid theoretical ground.
- The scoring criteria based on TeMPS can be made less subjective.
Limitation and Future Work: PerGO

• PerGO will be extended
  – more perspectives such as sociality, network communication, architecture, etc.

• PerGO will be refined and evolved
  – the concepts can be refined and evolved by carrying out more case studies.
Limitation and Future Work:

GCCT

• GCCT will be extended
  – More aspects of game creation may be explored
    • management,
    • document transitions, and
    • participants’ cooperation

• GCCT will be further evaluated and refined
  – The ultimate goal is to improve the overall process of model driven game development
  – The *practical environment and tools* to support the usage of PerGO and GCCT should be constructed and enhanced.
  – *Benchmark game applications* need to be developed.
  – *Larger scale user experiments* and surveys can be performed to allow external participants to *try out* the approach and provide comments.
  – More participants from the game *industry* might be recruited.
• Thanks!