



Introducing
Casanova 2, a
pragmatic
domain
specific
language for
game
development

**Mohamed
Abbadi**

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A brief
introduction
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Are we
missing a
language?

Abstraction
mismatch

Existing
solutions

Introducing Casanova 2, a pragmatic domain specific language for game development

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Lecture topics

- The relevance of games and beyond
- A brief introduction to game architectures
- Are we missing a language?
- Casanova as a first step towards a solution
- Current state of progress



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The relevance of games and beyond



The relevance of games and beyond

Background

- Games are a huge market (billions of worth, countless hours spent)
- Changing the entertainment landscape, overtaking music and movies
- Large industry, with lots of technical innovation and inspiring work

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Beyond entertainment

- The success of games is inspiring more and more people
- What if we can make other stuff as engaging?
- And so, *serious games* are born



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Serious games

- Using game mechanics to bring serious applications to life
- Simulators, training applications, rehabilitation, school, and much more
- Countless applications could benefit from games, accelerating progress and culture from many angles



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What is stopping us?

- Great, so where is my “learn math by blowing zombies up” game?
- Serious games makers do not have huge resources
- Here comes the problem: **games are very hard and expensive to build**



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What is stopping us?

- Great, so where is my “learn math by blowing zombies up” game?
- Serious games makers do not have huge resources
- Here comes the problem: **games are very hard and expensive to build**
- **This heavily impacts the viability of games in such innovative applications**

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Our take

- Our goal is to study and optimize the technical aspects of game development
- We look for complexity in the process and try to automate it
- We focus on the *programming languages* side of the equation^a

^aThere are many others!



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A brief introduction to game architectures



A brief introduction to game architectures

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The game loop - a source of complexity

- Games need to run in real time
- Frames must be sent to the screen at 30/60Hz
- It's all a big loop!



A very simplified game architecture

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```
1 state = GameState()
2 while Running:
3     state = update(state, dt)
4     state.Draw()
```



A brief introduction to game architectures

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The game loop - a source of complexity

- update covers the dynamics of the game
- The game is a *hybrid system*
- The continuous parts are simple: just integrate numerically ($P = P + V * dt$)
- The discrete parts are less simple: large concurrent state machines!



Discrete architectures

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```
1  switch action:
2      case RUNNING:
3          ...
4      case FIGHTING:
5          ...
6          ...
```

The game loop - a source of complexity



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1
2
3
4
5
6

```
switch action:  
  case RUNNING:  
    ...  
  case FIGHTING:  
    ...  
    ...
```

The game loop - a source of complexity

- That's not how we think!



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Idea

- Most of what makes a game a game is the discrete part of the dynamics
- Create interesting patterns that introduce *controlled* variation
- These dynamics define game logic, AI, and more



Specification of discrete dynamics

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```
1 repeat
2   for c in checkpoints:
3     velocity = normalize(c - position)
4     wait (distance(position, c) < 1m)
5     animation = look around
6     wait 3s
```

Idea



Specification of discrete dynamics

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2   for c in checkpoints:
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4     wait (distance(position, c) < 1m)
5     animation = look around
6     wait 3s
```

Idea

- Now imagine the “big switch” to implement this



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Idea

- The description of these dynamics is usually difficult to find back in code
- In this translation we lose a lot of the original intention
- It is harder to maintain, extend, and experiment with code



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Idea

- There are possible solutions (threads, strategy pattern, monadic coroutines, etc.)
- They all suffer from performance drawbacks, and have lots of hidden complexities



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Casanova as a first step towards a solution



Casanova as a first step towards a solution

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Idea

- We will now present Casanova, a domain specific language (DSL) for game development
- The language has time as a first class primitive
- All computations are specified as transformations of the state
- Continuous and discrete dynamics are both directly supported



Continuous dynamics

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```
1  entity Asteroid = {  
2      inherit UnityAsteroid  
3      Velocity : Vector3  
4  
5      rule Position = Position + Velocity * dt  
6  
7      Create() =  
8      {  
9          Velocity      = new Vector3(...)  
10         UnityAsteroid = UnityAsteroid.Instantiate(...)  
11     }  
12 }
```



Discrete dynamics

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```
1 worldEntity World = {  
2   inherit UnityBob  
3  
4   rule Velocity, CurrentAnimation =  
5     for c in Checkpoints do  
6       let dir0 = c - Position  
7       yield dir0, BobAnimation.Walk  
8       wait Vector3.Dot(dir0, c - Position) < 0.0f  
9       yield Vector3.zero, BobAnimation.Idle  
10      wait 1.0f  
11  
12  Create() =  
13    {  
14      UnityBob = UnityBob.Find()  
15    }  
16 }
```

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Ok, surely it does not work?

- We have been eating our own dog food quite extensively :)
- We have built a lot of samples and smaller games with Casanova



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Ok, surely it does not work?

- We have been eating our own dog food quite extensively :)
- We have built a lot of samples and smaller games with Casanova
- The good: quite simply, **it works**
- The bad: has a bit of a learning curve

Casanova as a first step towards a solution

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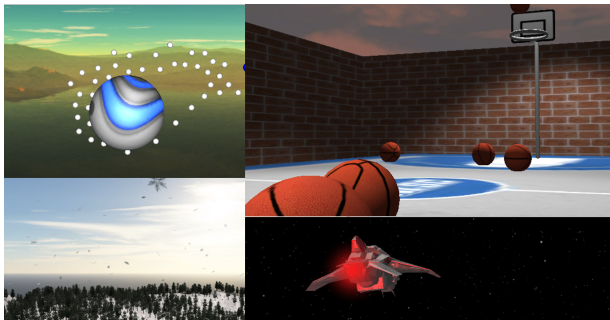
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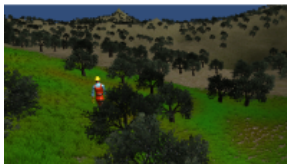
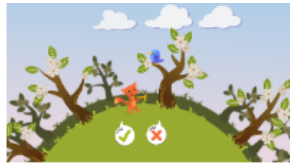
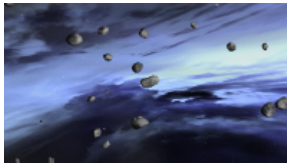
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Demo

• www.youtube.com/watch?v=_dE3EQ_aPbE&sns=em



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Casanova design



Syntax

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```
1 <Program> ::=
2   <moduleStatement> {<openStatement>}
3   <worldDecl> {<entityDecl>}
4
5 <moduleStatement> ::= module id
6 <openStatement>   ::= open id
7 <worldDecl>       ::= world id ["("<formals>")"] =
8                   <worldOrEntityDecl>
9 <entityDecl>      ::= entity id ["("<formals>")"] =
10                  <worldOrEntityDecl>
11 <worldOrEntityDecl> ::= "{" <entityBlock> "}"
12 <entityBlock>    ::= {<fieldDecl>} {<ruleDecl>}
13 <create>
14 <create> ::= Create "(" {<formals>} ")" = <expr>
15 <formals>  ::= id [":" <type>] {"," <formals>}
16 <fieldDecl> ::= id [":" <type>]
17 <ruleDecl>  ::= rule id {"," id} "=" <expr>
18 <type>      ::= int | boolean | float | Vector2
19             | Vector3 | string | char
20             | list "<" <type> ">" | <generic>
21             | <type> "[" "]" | id
22 <generic>   ::= ">" id
23 <expr> ::= ...(* typical expressions : let, if,
24             for, while, new, etc. *)
25             | wait (<arithExpr> | <boolExpr>)
26             | yield | <arithExpr> | <boolExpr>
27             | <literal> | <queryExpr> | <seq>
28 <seq>      ::= <expr> <expr>
29 <arithExpr> ::= ...//arithmetic expressions
30 <boolExpr>  ::= ...//boolean expressions
31 <literal>   ::= ...//strings, numbers
32 <queryExpr> ::= ...//query expressions
```

Semantics - re-write based

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```

1  E = { Field1 = f1; ...; Fieldn = fn;
2  Rule1 = r1; ...; Rulem = rm }
3
4  tick(e:E, dt) =
5    { Field1=tick(f1m, dt); ...; Fieldn=tick(fnm, dt);
6    Rule1=r'1; ...; Rulem=r'm }
7    where
8      f1m, ..., fnm, r'm = step(f1m-1, ..., fnm-1, rm)
9      .
10     .
11     f11, ..., fn1, r'1 = step(f1, ..., fn, r1)
12
13
14  step(f1, ..., fn, {let x = y in r'}) =
15  step(f1, ..., fn, r'[x:=y])
16
17  step(f1, ..., fn, {if x then r' else r''; r'''})
18    when (x = true) = step(f1, ..., fn, {r'; r'''})
19
20  step(f1, ..., fn, {if x then r' else r''; r'''})
21    when (x = false) = step(f1, ..., fn, {r''; r'''})
22  .
23  .
24  step(f1, ..., fn, {for x in [] do r'; r''})
25  step(f1, ..., fn, r'')
```



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Implementation



Implementation

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Compiler

- Casanova has its own compiler
- The first version used the open F# compiler as back-end
 - Pros: Fast to set up
 - Cons: lack of control over code transformations
- The current version is *layer based*. We wrote our own back-end, which now produces C#
 - Pros: complete control, C# can be run on several OS and tools
 - Cons: complex to build, scalability issues

Compiler

- Control over layers transformation and domain syntax and semantics allows code optimization
- Generated code uses low level constructs to achieve high performance

Table: Cnv performance

| Language | Time per frame |
|------------|----------------|
| Casanova | 0.07ms |
| C# | 0.12ms |
| JavaScript | 24.07ms |
| Lua | 20.90ms |
| Python | 20.15ms |

Table: Cnv vs Cnv opt

| Platform | Language | Optimized | Performance |
|----------|----------|-----------|-------------|
| Monogame | Casanova | No | 0.0159 ms |
| | Casanova | Yes | 0.0098 ms |
| | C# | - | 0.0147 ms |
| Unity3D | Casanova | No | 0.0257 ms |
| | Casanova | Yes | 0.0085 ms |
| | C# | - | 0.1642 ms |

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What is Casanova?

- Language features
 - It is a domain language
 - Hybrid (OO, Functional, Declarative)
 - Statically compiled
 - Performance oriented
- Compatibility (so far)
 - Unity (web, mobile, desktop)
 - Lego Mindstorm V3
 - Monogame
 - ...

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Usability

Ease of use

- An important part of my research
- Early results suggested us to compile Cnv into C# and to use Unity as rendering tool
- Cnv has been used for a year intensively by a group of 6 internship students
- 3 already done workshops on Casanova
 -  , latest workshop run at UoA
- Usability goals
 - Perfect the quality of our tools
 - Possibly adapt/introduce new features

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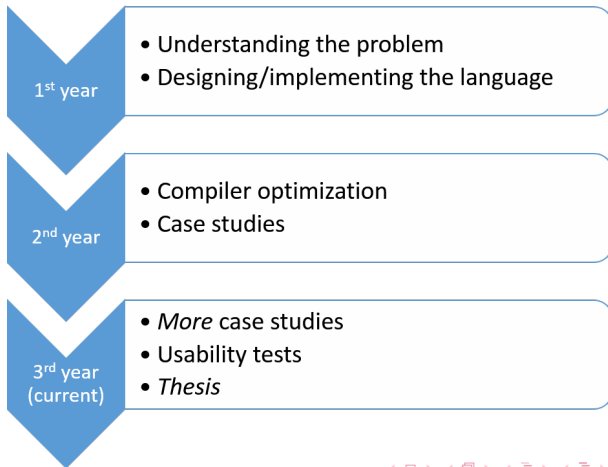
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Written contributions

Written contributions

Figure: Research progress



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Written contributions

Research progress

- Papers
 - Title: Resource Entity Action: A Generalized Design Pattern for RTS games (Springer)
 - Title: Casanova. A simple, high-performance language for game development (Springer)
 - Title: High performance encapsulation in Casanova 2 (IEEE)
 - Title: Making RTS games in Casanova (not submitted yet)
- Book chapter
 - Title: Serious Games (Springer)
- **LOTS** of Samples, workshop materials, and a collection of on-line tutorials



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Conclusion

- Game dynamics are hard to express
- By defining programming languages that support the building blocks of these dynamics, we can achieve higher productivity
- Games have a huge potential, and with Casanova we hope to unlock it
- <https://github.com/vs-team/casanova-mk2/wiki>



This is it!

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The best of luck, and thanks for the attention!