

Experience-Driven Procedural Content Generation

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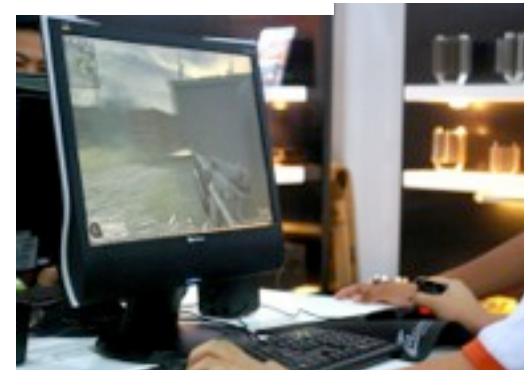


Key terms

- * **Player experience**
 - * The synthesis of affective patterns elicited and cognitive processes generated during gameplay
- * **Player experience modeling**
 - * Estimating the function between game content and player experience
- * **Procedural content generation**
 - * The automatic generation of game content

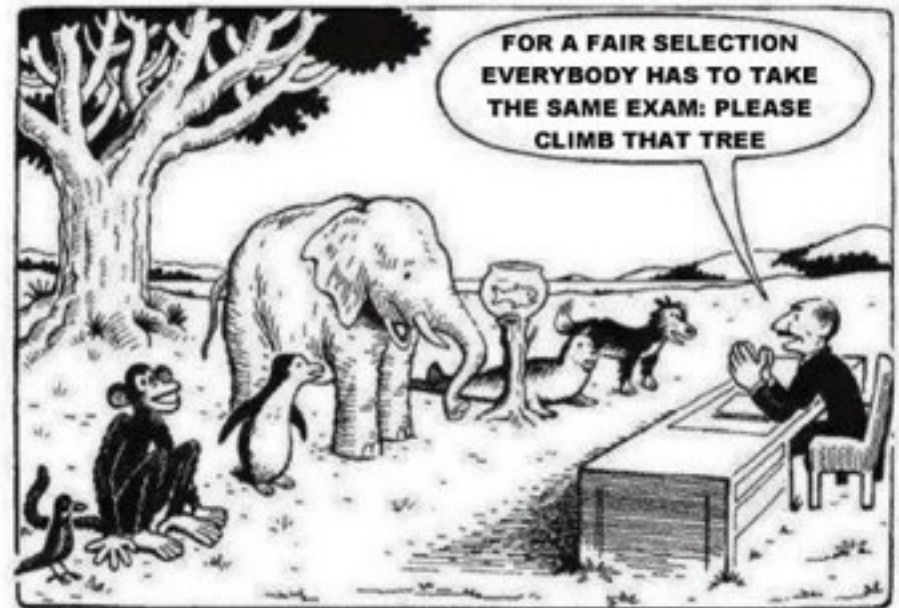
Motivation

- * Computer games are becoming more popular
- * Generating immersive games is the holy grail of game design



Motivation

- * Players are different
- * More information is becoming available
- * Automatic generation of personalized content will benefit both players and game designers



OUR EDUCATION SYSTEM

Problems?

- * Quantitative entertainment formulation
- * Better understanding of the player-content relationship
- * Implementing and integrating



The goals

- * Construct models of player experience
- * Build an efficient adaptation mechanism

What are the challenges?

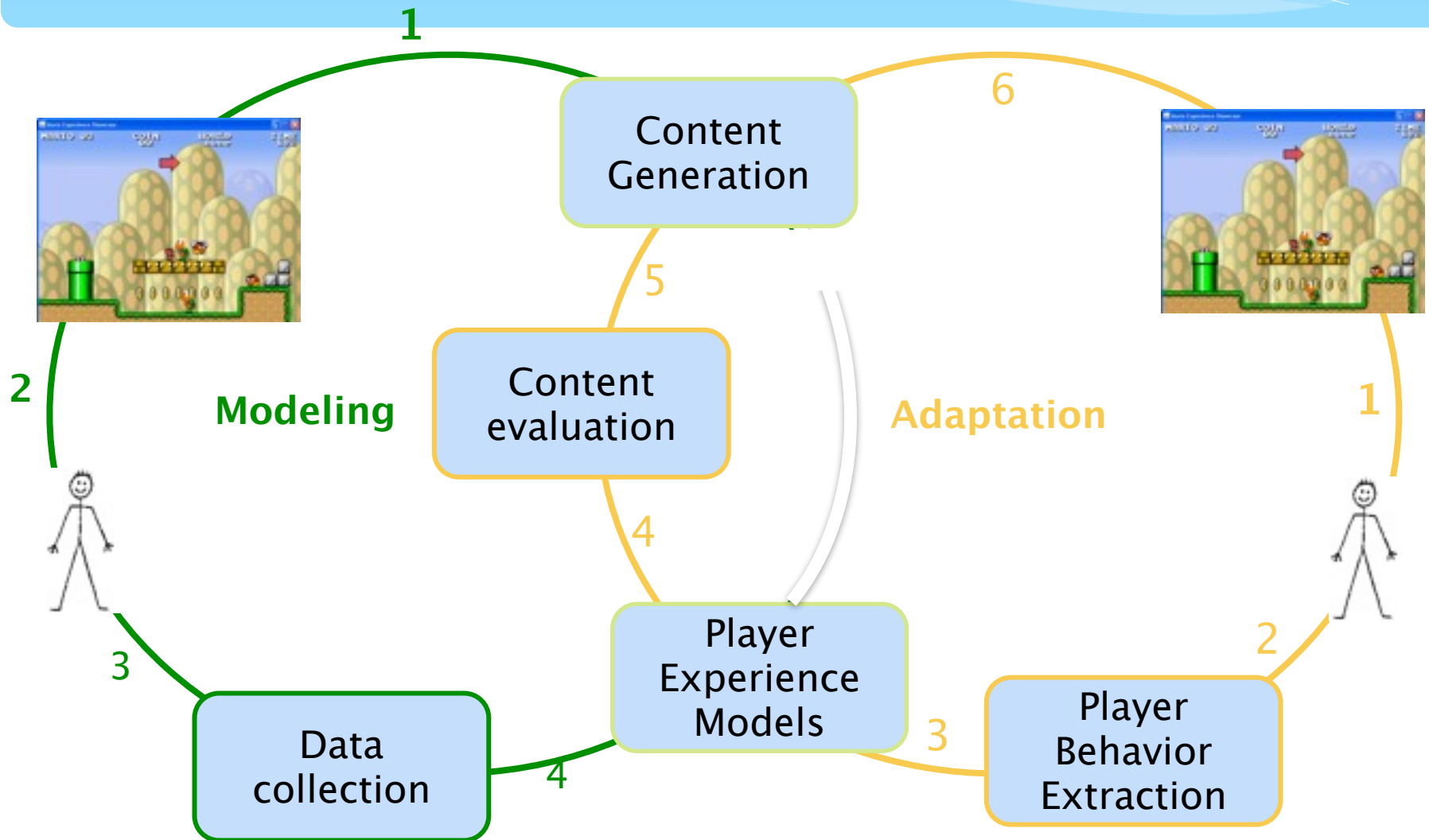
- * Recognizing players' affect
- * Understanding how affect is manifested via behavior
- * Representing context and behavioral information
- * Learning the relationship between context, behavior and affects
- * Adapting game content



The quantitative approach

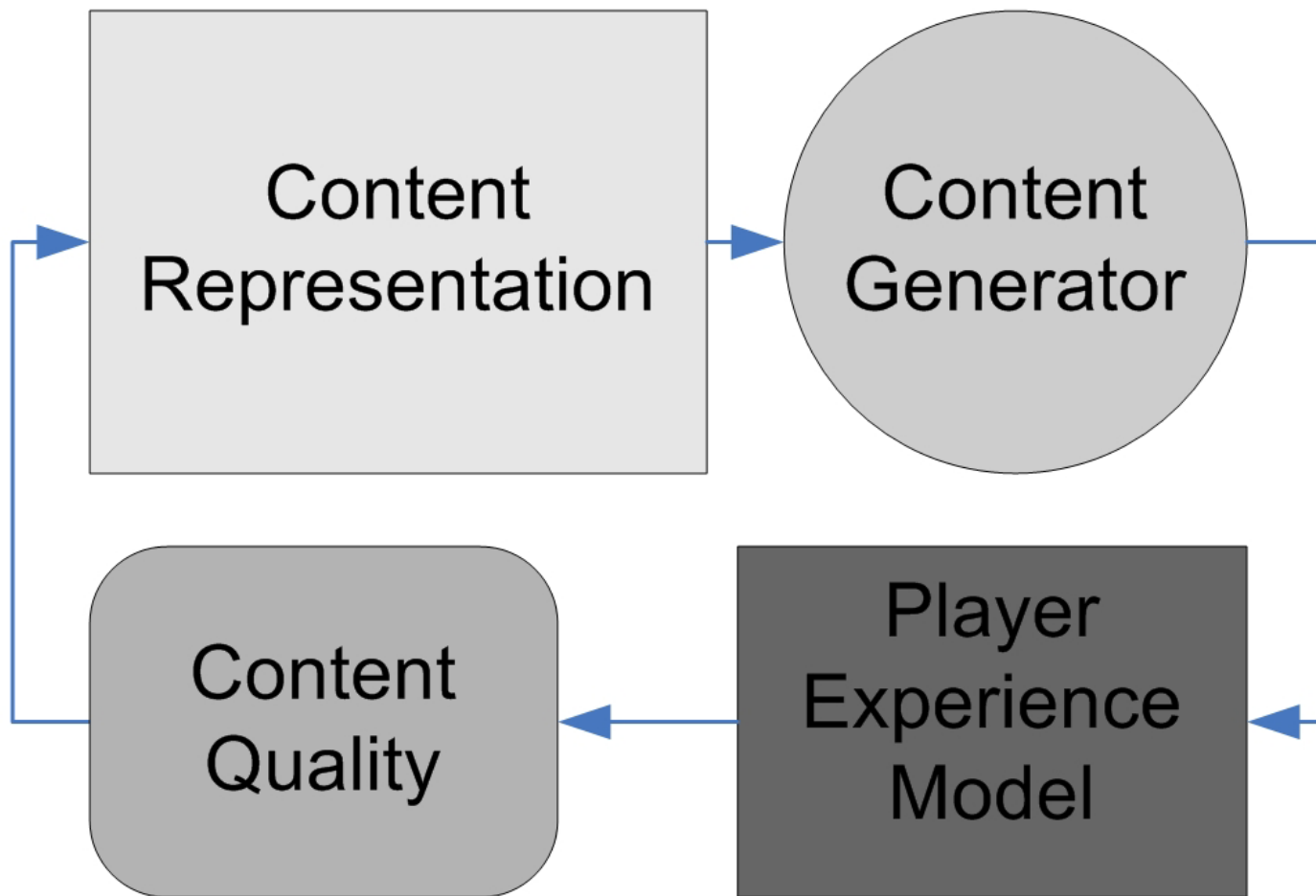
- * Crowd-source game interaction data from players
- * Model the relationship between game content and player behavior
- * Assess game content quality using the constructed models
- * Build content generators that explore the content space efficiently
- * Apply an adaptation mechanism to generate personalized content

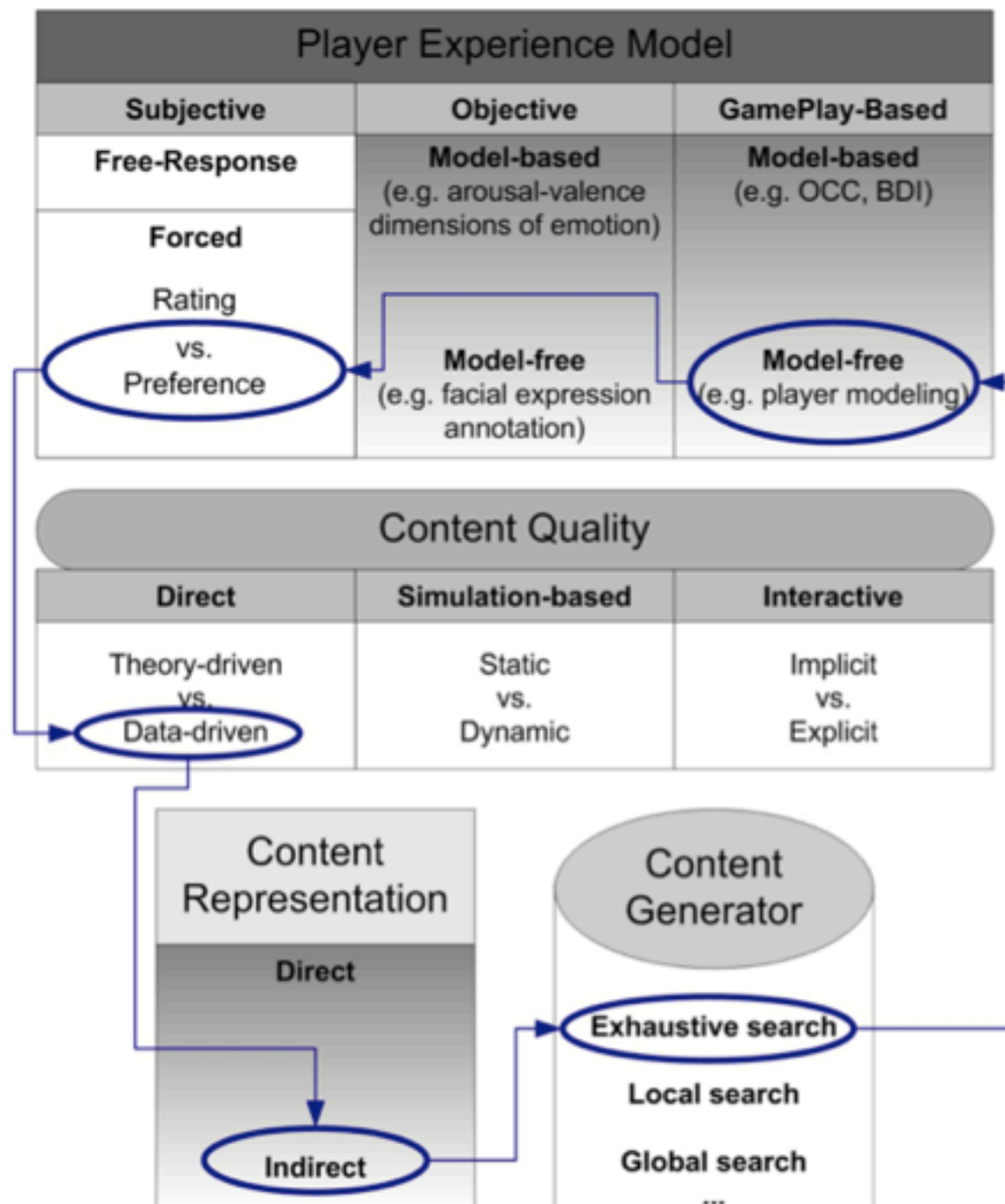
Framework



ED-PCG Framework

- * Player experience modeling
- * Content quality
- * Content representation
- * Content generator







Crowd-sourcing Player Experience

Crowd-sourcing

- * Why?

- * Build quantitative models of player experience
- * Allow data-driven automatic adaptation

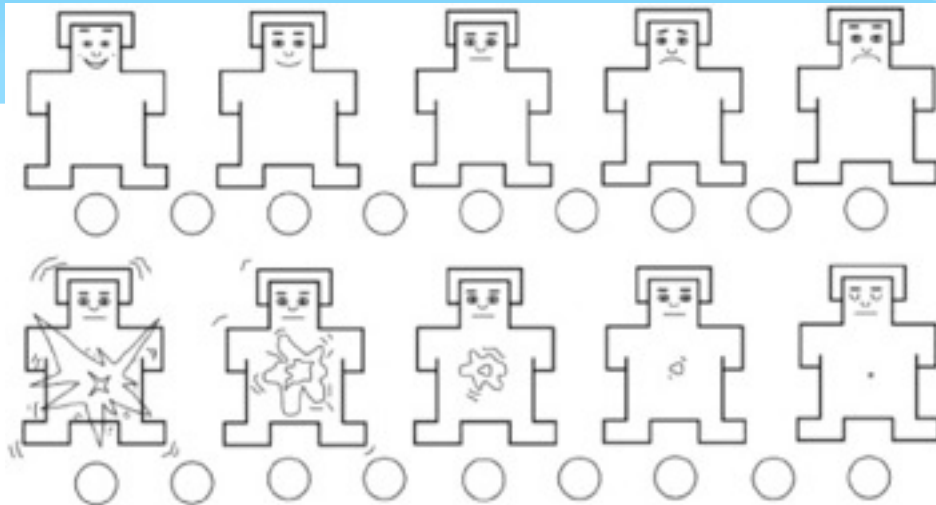
- * How?

- * Generate content
- * Evaluate content by players
- * Collect data about player behavior



Capturing Player Experience

How to capture player experience-subjectively



How to capture player experience—Objectively



How to capture player experience—gameplay



How to capture player experience-hybrid



Minecraft



Gameplay data gathering

TABLE I
Summary of General Statistics in Minecraft

Statistic	Mean	SD	Min	Max
Hours Played	53,37	67,64	0,69	450,54
Times Played	62,17	121,15	0,00	617,00
Worlds Played	8,20	13,60	0,00	90,00
Saves Loaded	32,56	91,84	0,00	563,00
Multiplayer joins	110,94	129,15	0,00	571,00
Games quit	113,86	139,65	1,00	613,00
Distance Walked	183274,4	290325,01	1014,58	1924954,44
Distance swam	4565,62	6815,38	1,16	46683,79
Distance Fallen	7303,75	13662,61	0,00	89619,87
Distance climbed	1487,33	2916,28	0,00	24624,31
Distance Flown	36733,01	55700,29	1,07	311901,45
Distance dove	2455,68	3608,00	0,00	22267,80
DistanceMinecart	4203,60	15928,94	0,00	135254,50
Distance by boat	3532,47	6238,62	0,00	28066,95
Distance by mine	8,72	28,26	0,00	214,20

Subjective questionnaire

TABLE II

Average player's profile (** strongest, * >0.5 stronger than average)

Statistic	Mean	SD
Acceptance	-0,6279*	1,364
Curiosity	0,9767**	1,355
Eating	0,3140	1,191
Family	0,0698	1,196
Honor	0,5698*	1,164
Idealism	0,6977*	1,311
Independence	0,6977*	1,293
Order	-0,4302	1,306
Physical activity	-0,1977	1,509
Power	-0,0930	1,271
Romance	-0,2093	1,209

Players' life motives

Acceptance	Curiosity	Eating	Family
Bookshelf M -0.297*	Cobblestone P 0.365**	Compass C 0.332*	Gold Sword U -0.34**
Mycelium M 0.256	Stone Shovel D 0.36**	Bricks M -0.326*	Gold Sword D -0.334*
Fire Charge U 0.253	Stone Axe C 0.358**	Vines P -0.297*	Cobblestone M -0.318*
Snow M 0.249	Stone Shovel U 0.355**	Clay M -0.284*	Cactus M -0.316*
Iron Sword D -0.24	Torch M 0.339**	Stone C 0.257	Stone Hoe U -0.311*
Honor	Idealism	Independence	Order
Lapis Block C 0.336*	Stone Sword U -0.335*	The End? -0.371**	Sprucewood stairs M -0.283*
Stone Pickaxe D 0.322*	dead shrub M -0.329*	The End -0.345**	Iron Pickaxe C -0.272

Content generators

- * Content can be:
 - * Story
 - * Graphics
 - * Sound effects
 - * Mechanics
 - * Items
 - * Maps/levels
 - * rulesets

Evaluating game content

- * Direct
- * Simulation-based
- * interactive

Optimizing game content for experience

- * Content representation
- * Content generation

Case study: Super Mario Bros



Content generation

- * Content can be:

- * Story
- * Graphics
- * Sound effects
- * Mechanics
- * **Items**
- * Maps/levels
- * rulesets

Content generation in Super Mario Bros



Grammatical evolutionary generator

- * Level = list of chunks
- * Each chunk can be
 - * A gap
 - * An enemy
 - * A box
 - * A platform
 - * A hill
- * Each chunk has a list of parameters
- * E.g. Level = platform(position, width)
gap(position, width) enemy(position, type)

Design Grammar

```
<level> ::= <chunks> <enemy>
<chunks> ::= <chunk> | <chunk> <chunks>
<chunk> ::= gap(<x>, <y>, <wgbeforeafterbeforeafterbeforeaftercbeforeafterbeforeafter2 | ...
           | <box_type> (<x>, <y>)6

<box_type> ::= blockcoin | blockpowerup
             | rockcoin | rockempty

<enemy> ::= (koopas | goompas) (<x>)2 | ...
           | (koopas | goompas) (<x>)10
<x> ::= [5..95] <y> ::= [3..5]
```

Experimental Protocol

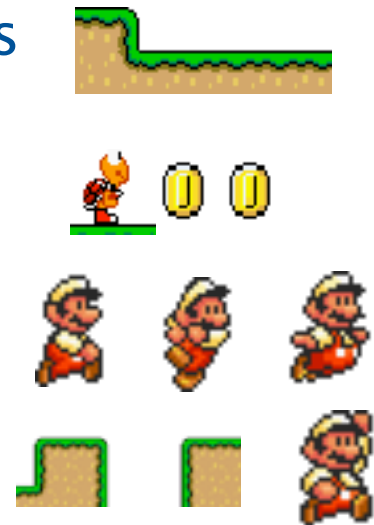
- * Present pair of games
- * Collect player behavioral information (gameplay and visual reaction)
- * Ask players to report their experience (4-AFC)
 - * Engagement
 - * Frustration
 - * Challenge

Types of data

- * Content data
 - * Direct features (controllable)
 - * Full structure of the levels
- * Gameplay data
 - * Direct features
 - * Interaction events
- * Head movement
- * Player experience
 - * 4-AFC (engagement, frustration and challenge)

Feature extraction

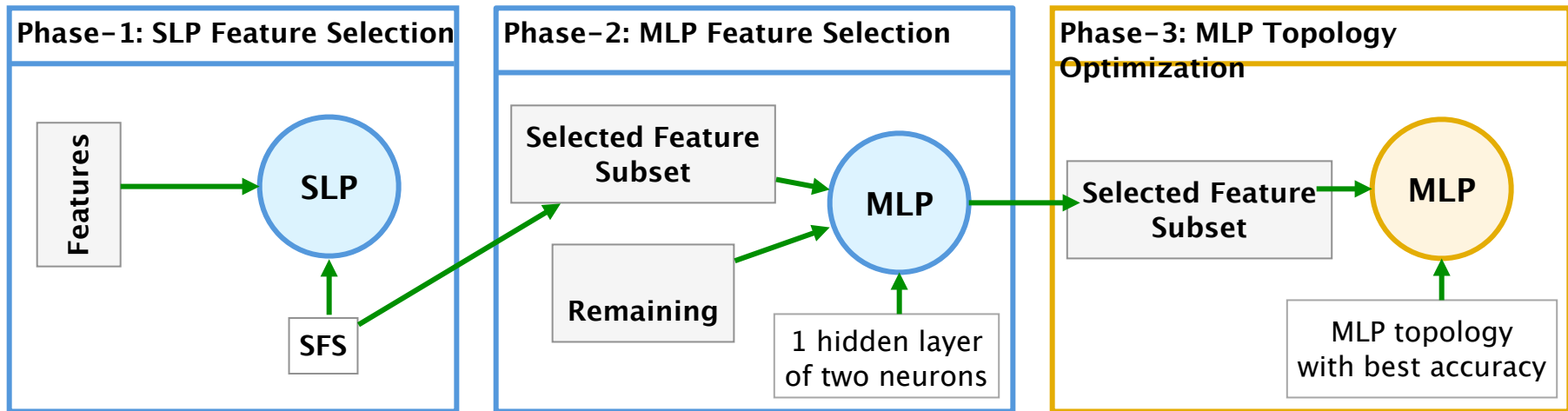
- * Direct representation
 - * Frequencies of items and interactions
- * Sequential representation:
 - * Frequent patterns of
 - * content features
 - * gameplay features
 - * Fused sequential features





Modeling Player Experience

PEM framework



Experiments: Dataset 2

- * High prediction accuracies for the three emotional states
 - * Engagement: **83.80%** from patterns of players' actions
 - * Frustration: **80.70%** from direct features
 - * Challenge: **86.28%** from fused features of direct and sequential patterns of game content and player behavior
- * Dataset 2
 - * Parameterized generator
 - * Content data
 - * Direct features
 - * Full level structure
 - * Gameplay data
 - * Direct features
 - * Interaction events
 - * Head movement
 - * Player experience
 - * 4-AFC
 - * 780 game pairs
 - * Levels of 100



Game Adaptation

Problems

- * How often?
- * How?
- * Evaluation?

Adaptation–How?

- * Use the constructed PEMs
 - * Adjust the models for control
- * Apply adaptation to optimize a particular experience
 - * Exhaustive search
 - * Global search

Exhaustive search

- * Capture player behavior
- * Search the space of controllable features
- * Select the combination that maximize/minimize the PEM output
- * Use this combination to generate the personalized content

Evolving personalized content

- * Capture player behavior
- * Generate random population of levels
- * Rank each level according to its appeal to the player
 - * Use the PEM
- * Evolve “better” levels

Evolving personalized content



Evolving personalized content



Evolving personalized content



Extract the values of
the
gameplay features

Evolving personalized content

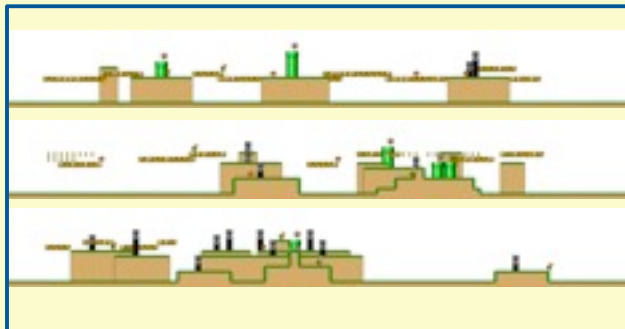


Extract the values of
the
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Evolving personalized content

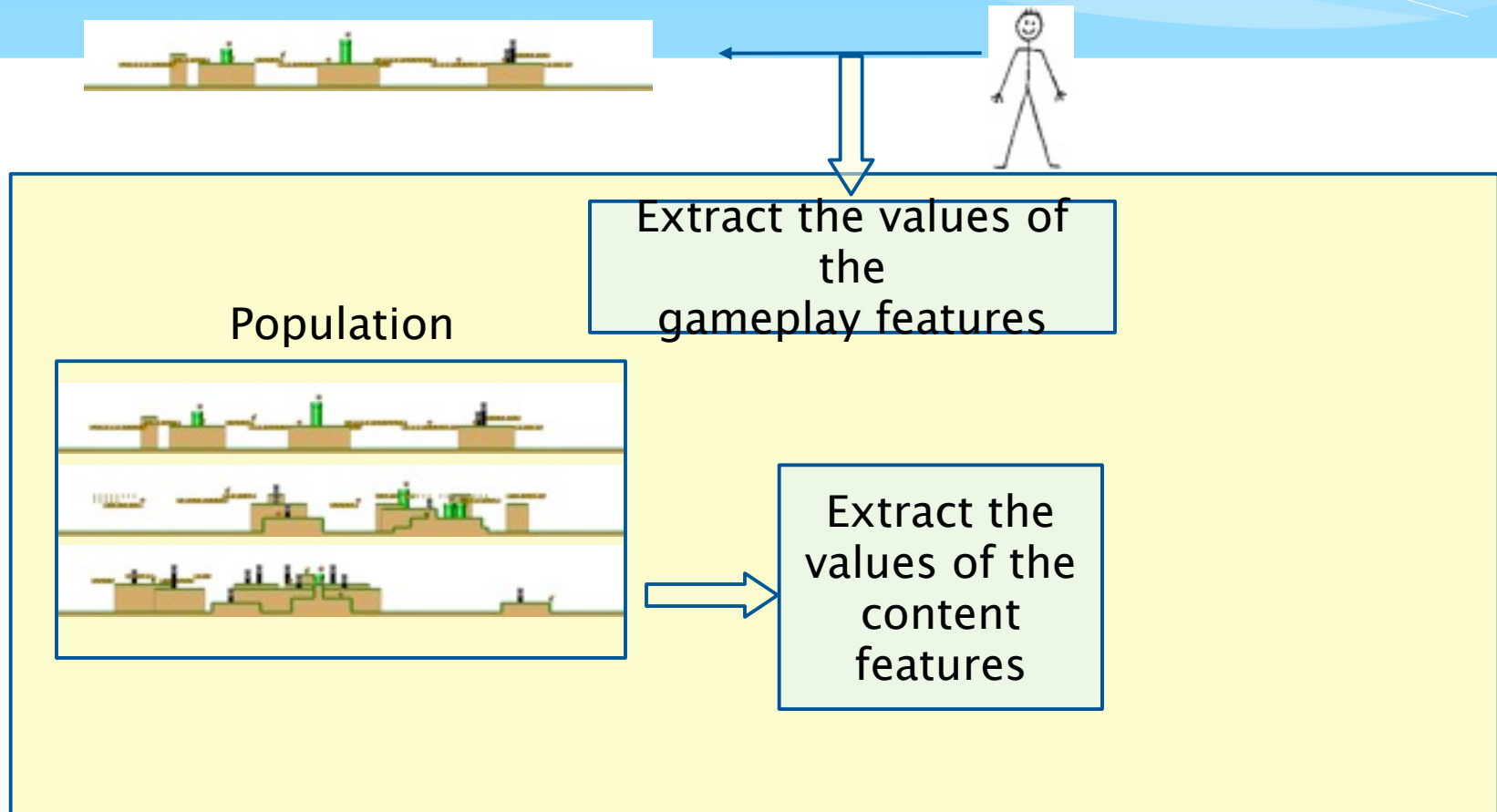


Population

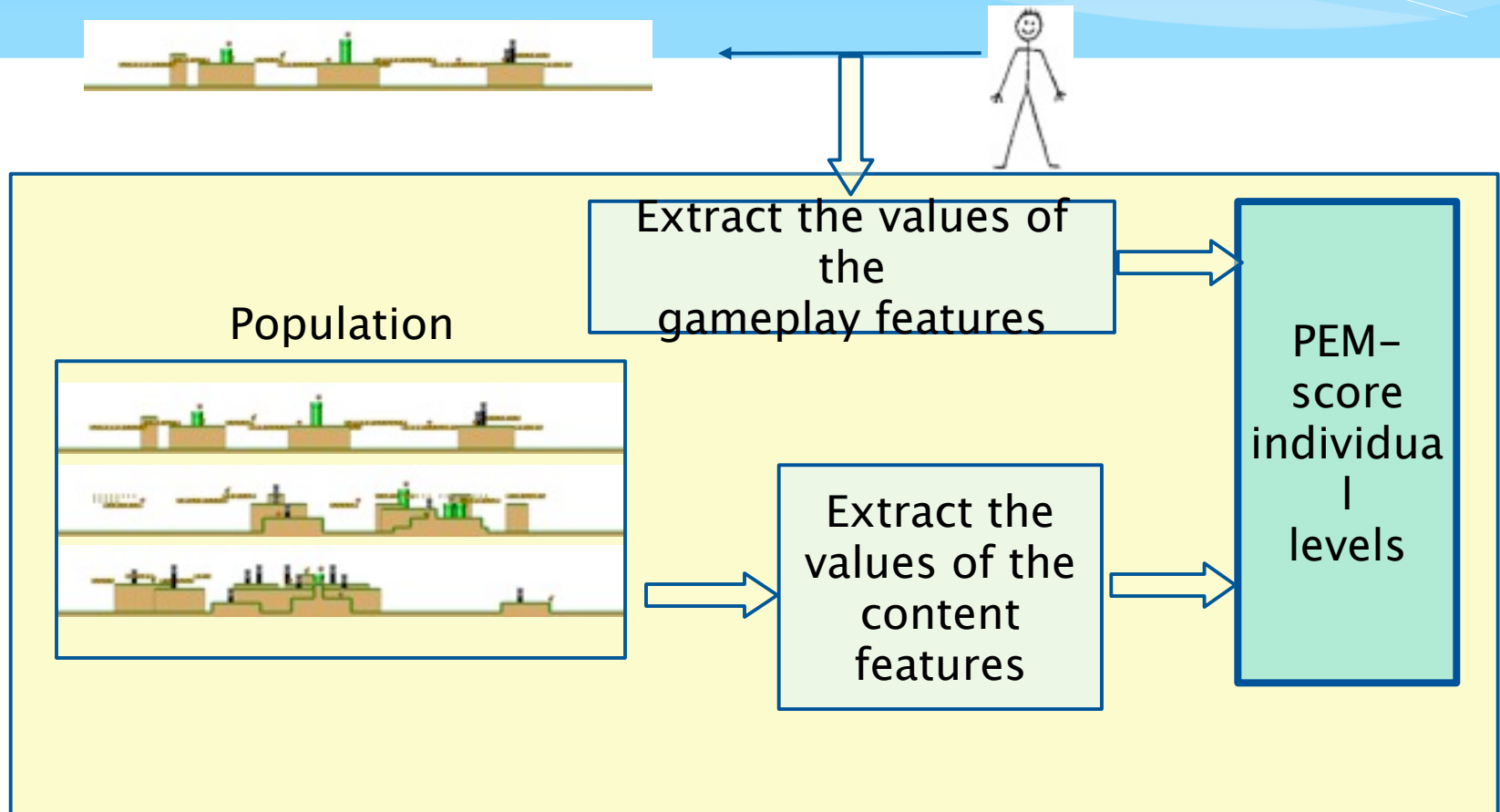


Extract the values of
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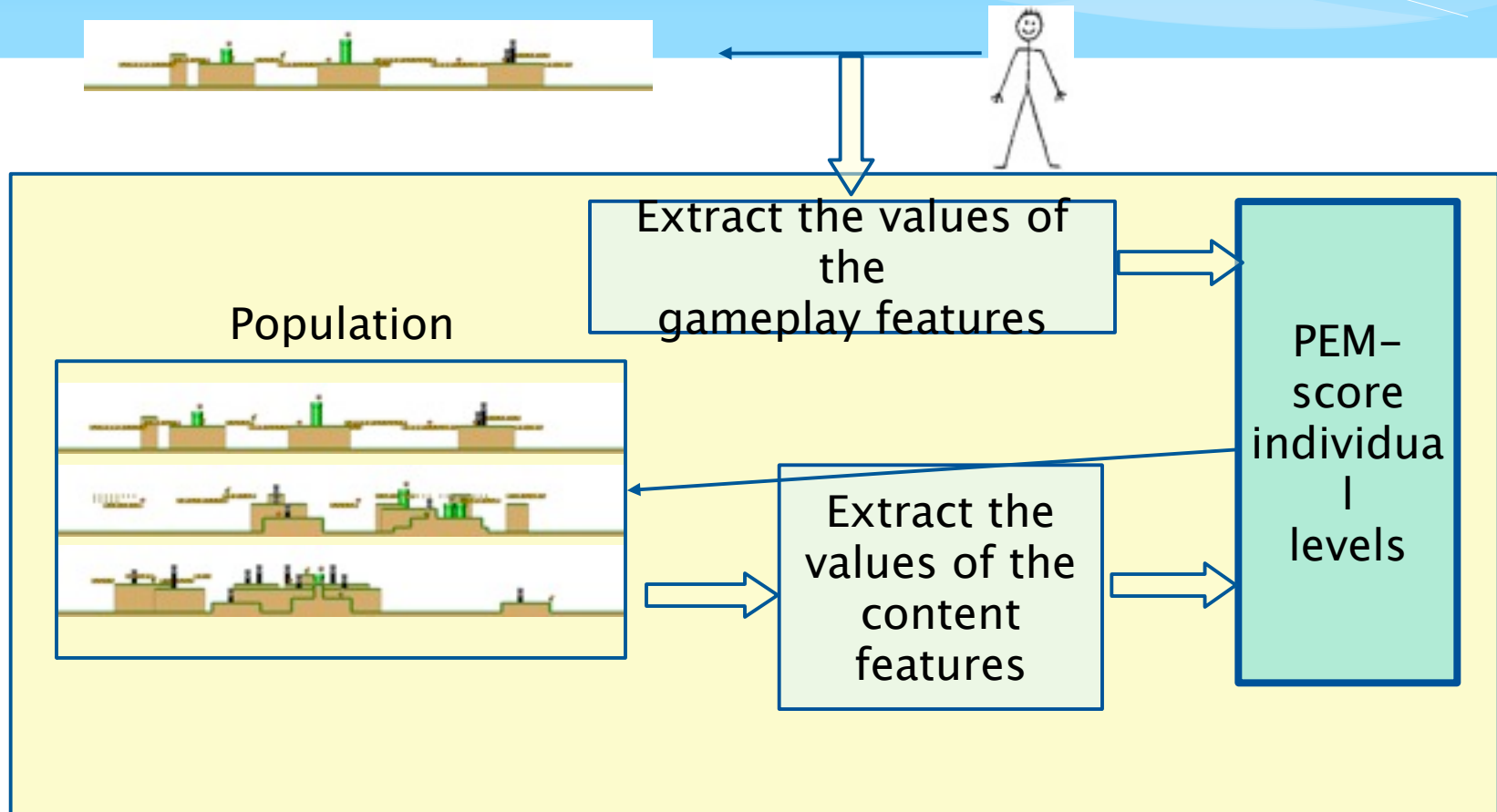
Evolving personalized content



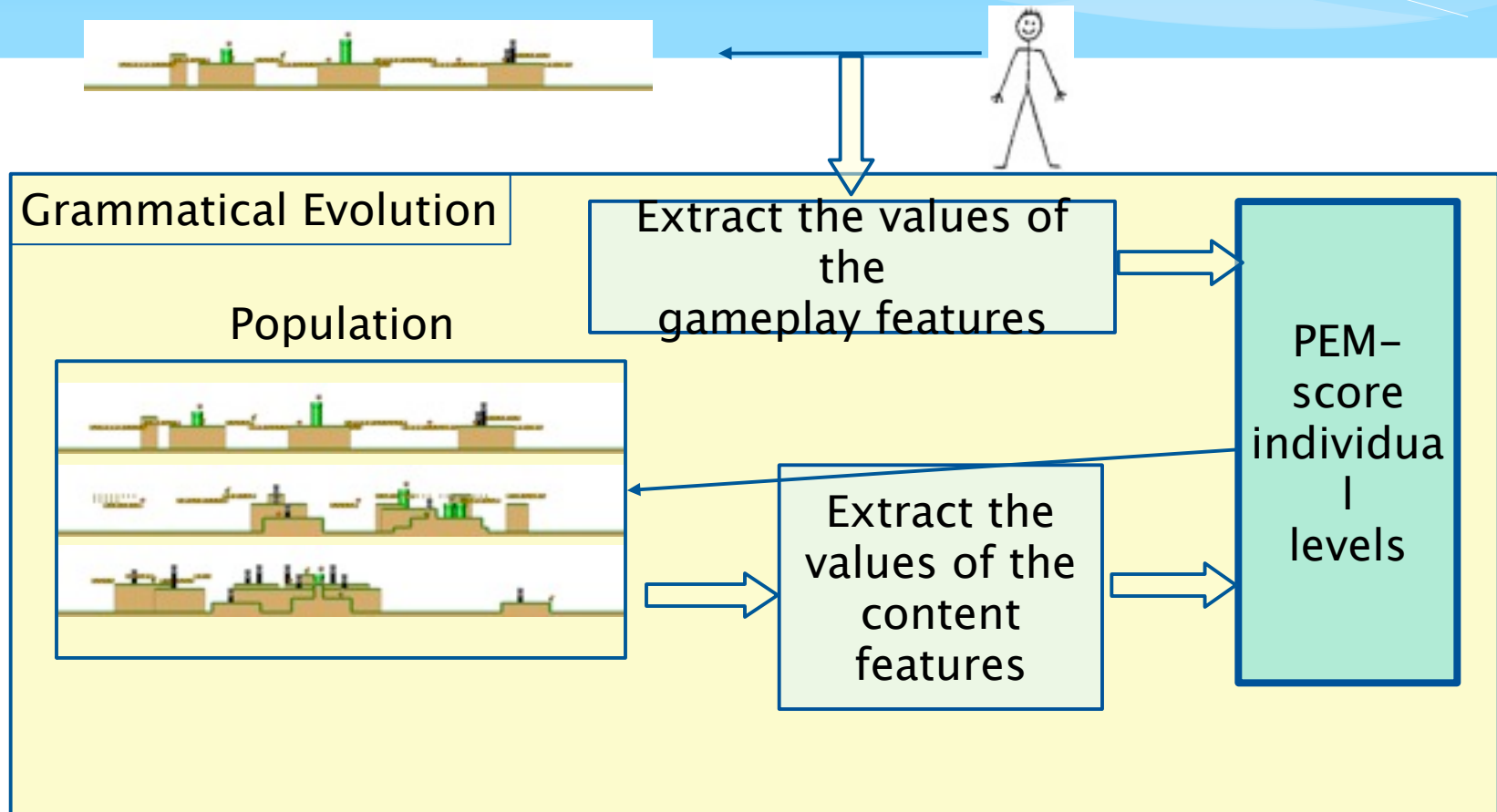
Evolving personalized content



Evolving personalized content



Evolving personalized content



Evaluation

- * Simulation-based approach
 - * AI agents