Using a Disjoint Skill Model for Game and Task Difficulty in Human Computation Games

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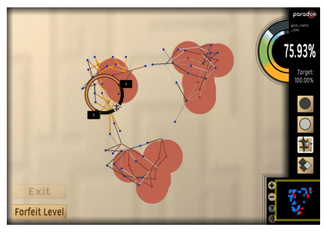
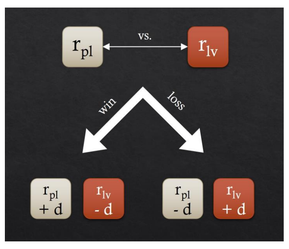
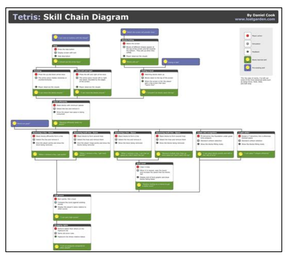
Introduction



Human computation games (HCGs) model computational tasks



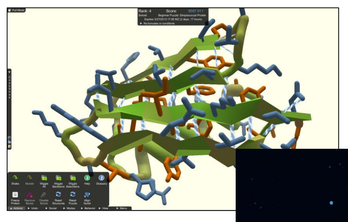
Rating systems are used in HCGs for dynamic difficulty adjustment via matchmaking



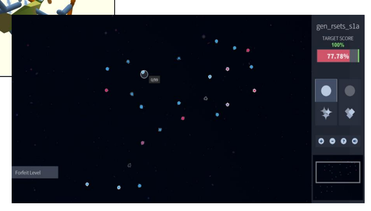
Skill chains are used in HCGs to craft progressions by defining order of skill acquisition

- Previous work assigned levels in HCGs a single rating and/or one set of skills to capture the combined difficulty of mechanics and tasks i.e. ***a joint skill model***
- But some HCGs exhibit ***disjoint design*** i.e. mechanics are not tied to the task, so levels may feature difficult mechanics but easy tasks and vice-versa

Joint and Disjoint Design

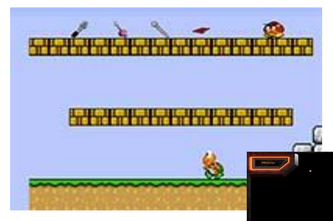


Foldit



Paradox

- Good at mechanics ⇔ good at tasks
- Joint skill models are sufficient!



Gwario

OnToGalaxy

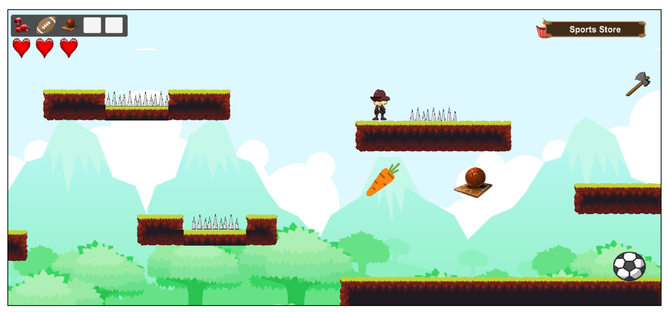
- Good at mechanics ⇏ good at tasks
- Joint skill models are not ideal!

We introduce a disjoint skill model for separately tracking player skill in performing game mechanics and solving computational tasks, thus enabling more informed difficulty balancing

Game and Task

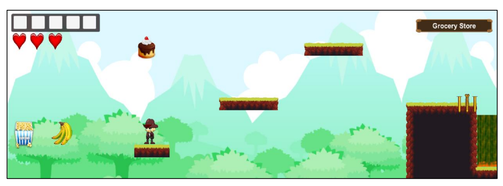
For demonstrating and evaluating the disjoint skill model, we used the game ***Iowa James: Hunter Collector Gatherer***, an HCG with 2D side-scrolling platformer mechanics that models the task of item collection, inspired by ***Gwario***.

Game: Iowa James Hunter Collector Gatherer

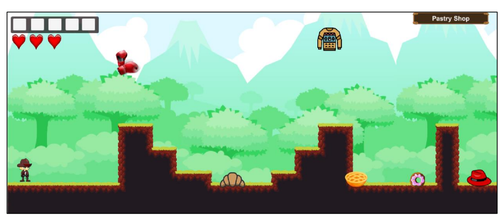


Task: Item Collection

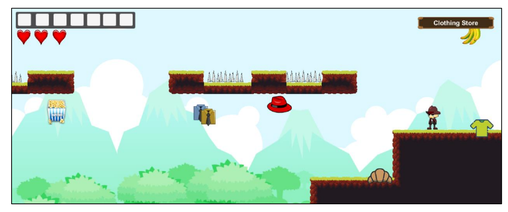
Grocery Store



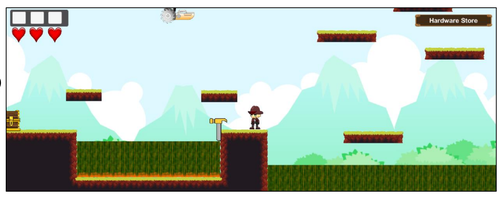
Pastry Shop



Clothing Store



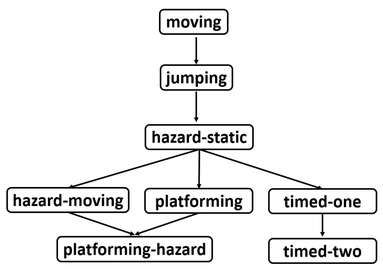
Hardware Store



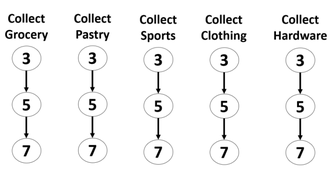
The task involves collecting items relevant to the given scenario while avoiding irrelevant items

Method

1. Skill Chain Definition



Game Skill Chain



Task Skill Chain

- Skill chains are directed graphs where nodes correspond to skills and edges correspond to skill dependencies
- Game skill chain captures progressively harder platformer mechanics
- Task skill chain captures collecting progressively more correct items
- Both skill chains were manually defined for this work

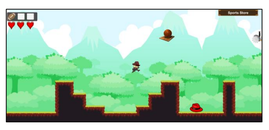
2. Annotation and Initialization

Game Rating: 1500

Task Rating: 1500

Game Skills: [ ]

Task Skills: [ ]



Rating: 1500

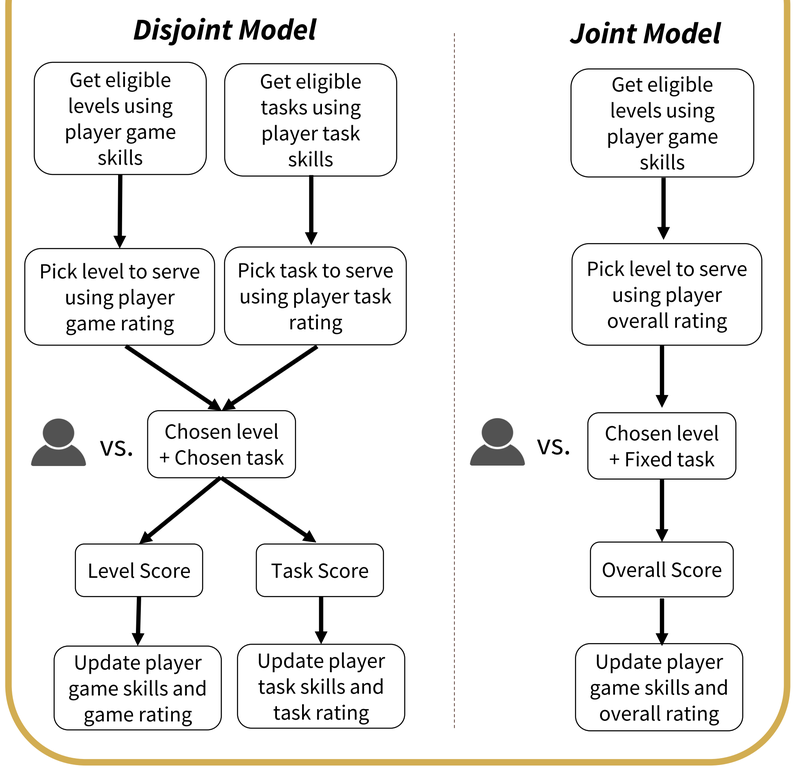
Skills: [jumping, moving]

Rating: 1500

Skill: [collect 3 sports items]

- All players, levels and tasks initialized with default rating of 1500
- Players start with no game and no task skills
- Levels annotated with required skills from game skill chain
- Tasks annotated with a skill from task skill chain

3. Level and Task Matchmaking



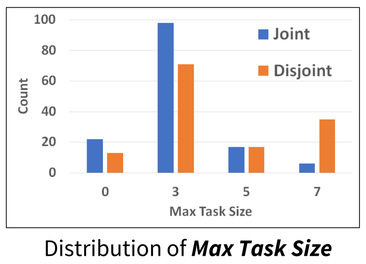
Evaluation Metrics

- ***Total Relevant Items Collected***
- ***Total Irrelevant Items Collected***
- ***Max Task Size:*** highest number of relevant items that the player was able to collect for any scenario (0, 3, 5, or 7)
- ***Max Level Skill Chain Magnitude:*** highest number of skills in the skill chain of any level that player completed
- ***Levels Completed***

Results

279 players randomly assigned to joint or disjoint model

- Disjoint model led to significant improvement in ***Max Task Size***
- ***Relevant Items Collected*** higher for disjoint model but not significantly



Distribution of ***Max Task Size***

	Joint	Disjoint
N	143	136
Relevant items ($p = .17$)		
median	15	16
mean	28.8	34.5
Irrelevant items ($p = .89$)		
median	8	9
mean	17.3	16.1
Max task size ($p < .001$)		
median	**3.0**	**3.0**
mean	**2.9**	**4.0**
Max level skill chain magnitude ($p = .12$)		
median	3	3
mean	2.9	3.1
Levels completed ($p = .39$)		
median	3	3
mean	3.5	3.9

Summary of values for metrics. Significant values in bold.

Conclusion

- Based on results, a ***disjoint model*** enables players to exhibit ***better task performance*** than a joint model that does not take task skill into account
- Under a ***joint model***, players ***may fail to acquire more complex task skills*** despite mastering the game's mechanics and vice-versa

Future Work

- Apply disjoint model to other HCGs with tasks more complex than item collection
- Investigate methods for automatically inferring game and task skill chains

Acknowledgments

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