THE UNEXPECTED CONSEQUENCE OF INCREMENTAL DESIGN CHANGES

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1. The goal of the game is to get your snakebird into the exit.
Snakebird Level 24
Solution length: 27

Solution length: 58
Exhaustive PCG (EPCG) in Snakebird

Find 1-step change that maximizes the solution length

Players found the resulting levels more interesting and challenging than the original levels
SELECTED RELATED WORK

PCG for Sokoban level generation
(Khalifa and Fayek, 2015; Bento, Pereira, and Lelis, 2019)

ASP for Refraction Puzzles
(Smith, Butler & Popovic, 2013)

Angry Birds
(Ferreira and Toledo 2014; Stephenson and Renz 2016; Jiang, Harada, and Thawonmas 2017)

Search-Based PCG (GA) for Baba is You
(Charity, Khalifa, and Togelius 2020)
EXHAUSTIVE PCG

Requires a generator G & evaluator E
G: Generator generates all content
E: Evaluator evaluates content

Return the “best” content
EPCG IN SNAKEBIRD

G: For all locations \((\text{width} \times \text{height})\)
   Change tile to sky/ground/spikes
   Ignore fruit, exit, snakebird

E: Perform Breadth-first search
   Measure optimal solution length
   Can choose min or max

Snakebird Primer Level 37
Modified Solution Length: 28
Snakebird
46 regular levels
6 difficult (star) levels
1 black hole level

Snakebird Primer
69 regular levels
6 difficult (star) levels
1 black hole level

108 of 129 levels easily solved
Does incremental EPCG lead to levels that are significantly different?

Do humans find the resulting levels interesting?

Snakebird Level 36
Solution Length: 55
DISTRIBUTIONS

Optimal Solution Length Distribution

- Min
- Original
- Max

Density vs. Solution Length
DISTRIBUTIONS

Optimal Solution Length Distribution

- **Density**
  - 0
  - 0.01
  - 0.02
  - 0.03
  - 0.04
  - 0.05

- **Solution Length**
  - 0
  - 20
  - 40
  - 60
  - 80
  - 100

- **Min**
- **Original**
- **Max**
1. The goal of the game is to get your anhinga into the exit.

2. Before you can exit, you must eat all the fruit in the level. Eating fruit makes your anhinga longer. *(Note that your anhinga can stand on top of fruit!)*

3. Be careful not to fall on spikes, as this will kill your anhinga. But, if you do, the game will undo your move so you can try again.
USER STUDY

Snakebird Level 0

Snakebird Primer Level 4

Snakebird Primer Level 5 (modified to teach spikes & standing on fruit)
USER STUDY

Before EPCG

Snakebird Primer 7
Snakebird Primer 19
Snakebird Primer 26
Snakebird Primer 28

After EPCG
SURVEY QUESTIONS

For level pairs:
• Which of the levels was most _____ to play?
  • fun, frustrating, surprising, challenging, interesting
• Overall, which of the levels did you most enjoy?

Across all four levels, what level did you think was best?
## SURVEY RESULTS

Is EPCG variation more:

<table>
<thead>
<tr>
<th></th>
<th>Fun</th>
<th>Surprising</th>
<th>Enjoyable</th>
<th>Interesting</th>
<th>Frustrating</th>
<th>Challenging</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>48.3</td>
<td>48.3</td>
<td>55.0</td>
<td>61.7</td>
<td>61.7</td>
<td>63.3</td>
</tr>
</tbody>
</table>

Which level is best?
- 65% EPCG Variant (p≪0.05)
- 35% Original Level

p<0.05
Levels are not necessarily better
Have to be put in context of game

Evaluator maximizes solution length
Other metrics may be better

Humans do not find optimal solutions
Can still give humans insight
CONCLUSIONS

- Incremental design have a significant impact in Snakebird
  - Level analysis
  - User study
- Online demo available
  - [https://movingai.com/snakebird-editor.html](https://movingai.com/snakebird-editor.html)
- Working on better mixed initiative / co-creative tools
MORE INFORMATION

- **Paper:**

- **Code:**

- **Demos:**
  - [https://movingai.com/snakebird.html](https://movingai.com/snakebird.html)
  - [https://movingai.com/snakebird-editor.html](https://movingai.com/snakebird-editor.html)
A DEMONSTRATION OF ANHINGA: A MIXED-INITIATIVE EPCG TOOL FOR SNAKEBIRD

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