



How King uses AI to test Candy Crush Saga

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King



- Founded 2003
- +200 Games
- 2000 employees
- 11 Locations (Stockholm, London, Barcelona, Berlin, Malmö, Bucharest, San Francisco, Chicago, Los Angeles, New York, Malta)
- 258 million monthly active users (Q2 2019)
- Acquired by Activision/Blizzard (2016-02-23)

Major Franchises

Candy
Crush



Pet
Rescue



Bubble
Witch 3



FARM
Heroes

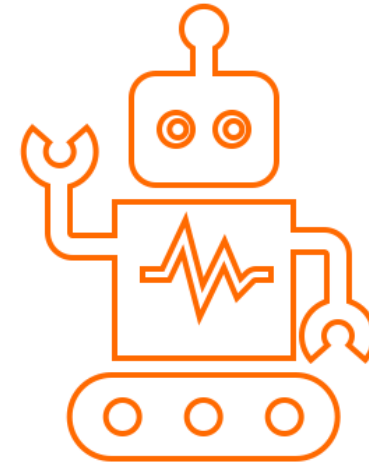


King QA roles



- ATL - Agile Testing Lead
- QA Analyst - Exploratory tester
- QRT - Quick Regression Team
- TAE - Test Automation Engineer
- DS - Data Scientist
- Developer - (Frontend/Backend)

BAIT – Bot for AI-based Testing

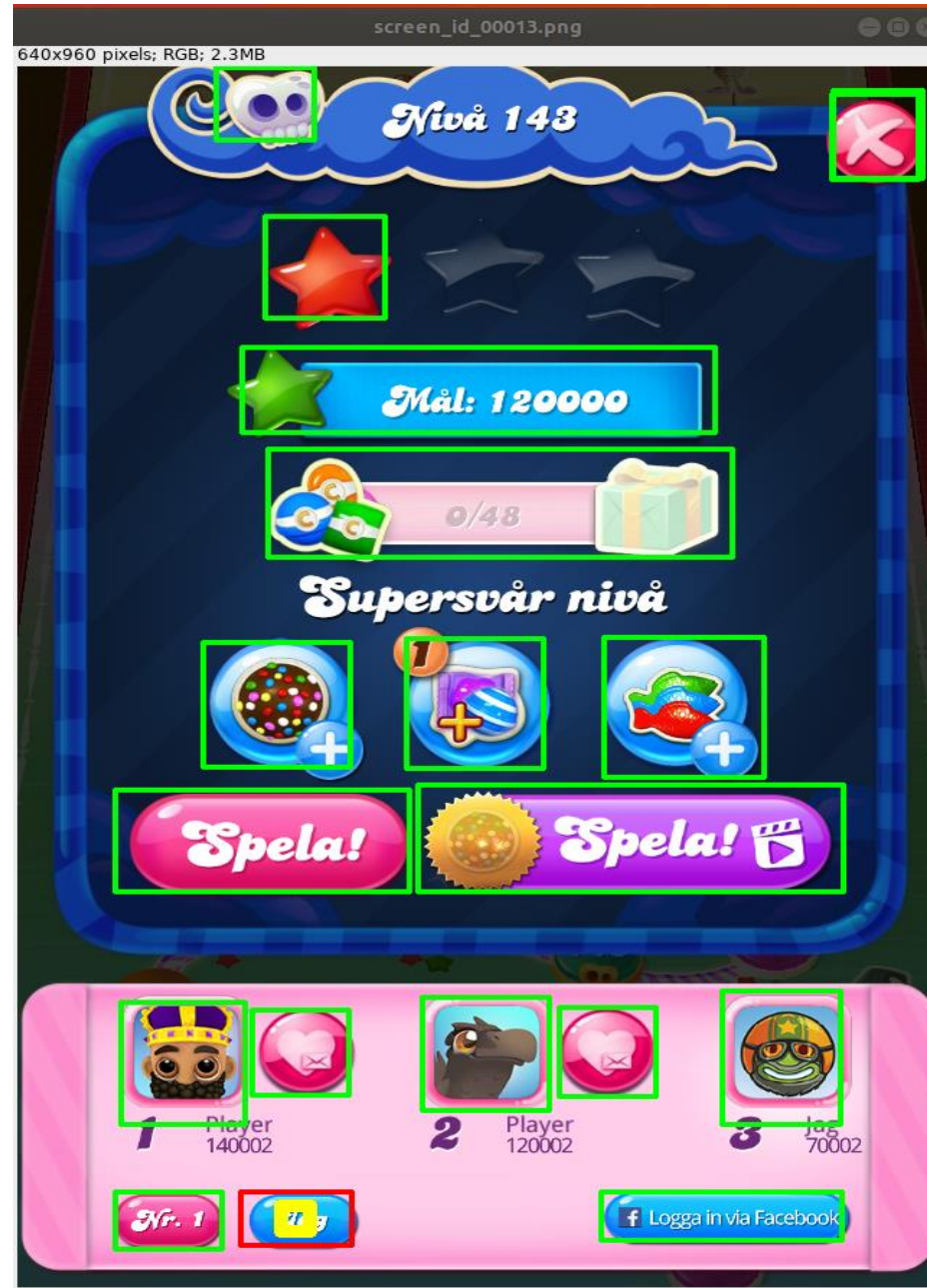


BAIT is a test automation bot powered by AI

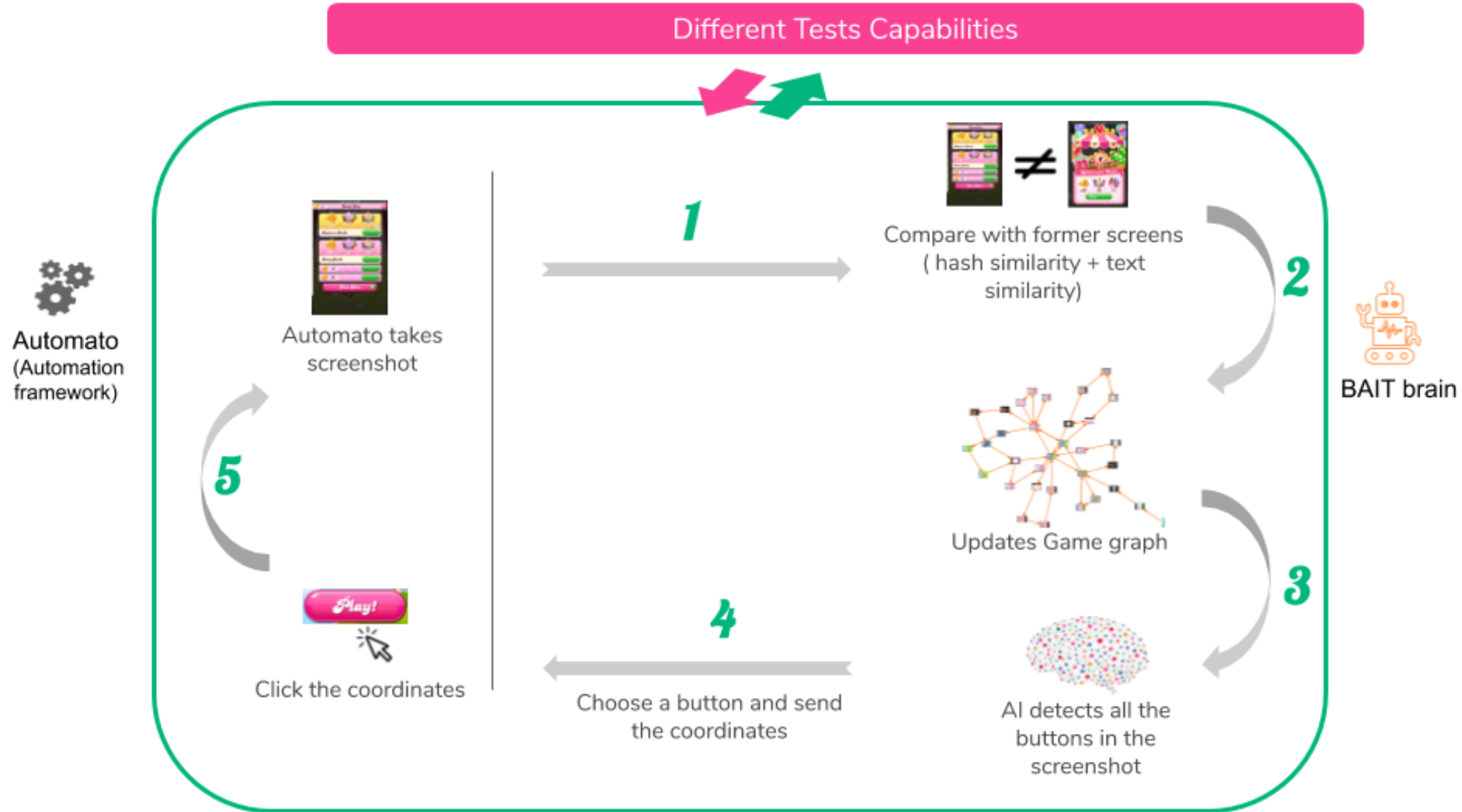
How does BAIT work?

Bait explores game by

- Taking screenshots
- Uses AI to find button coordinates
- Click detected buttons
- Performs AI powered verifications



BAIT workflow



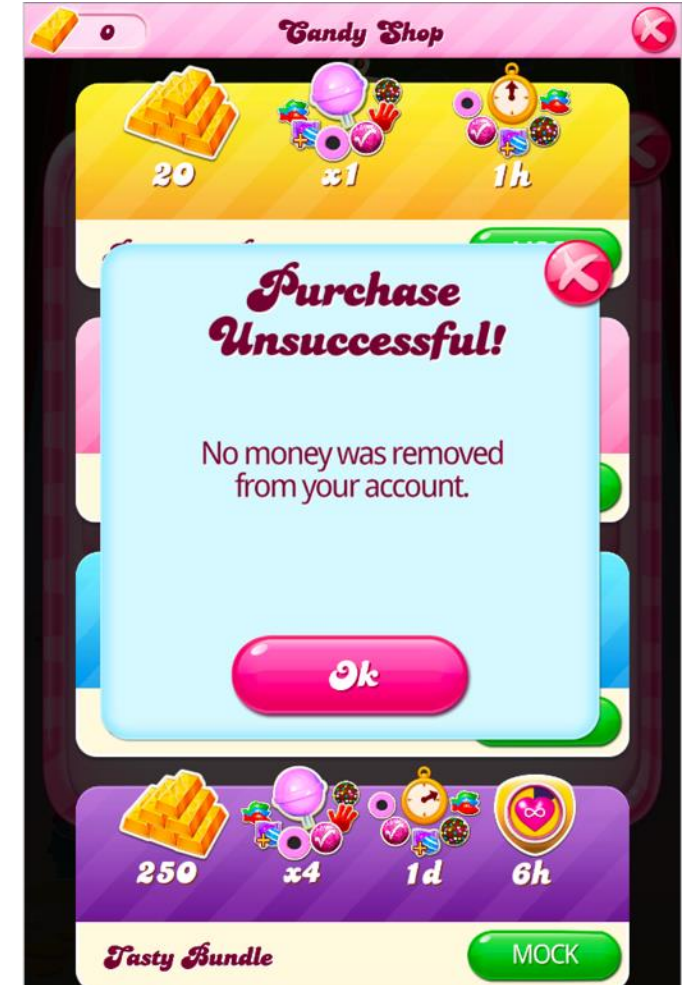
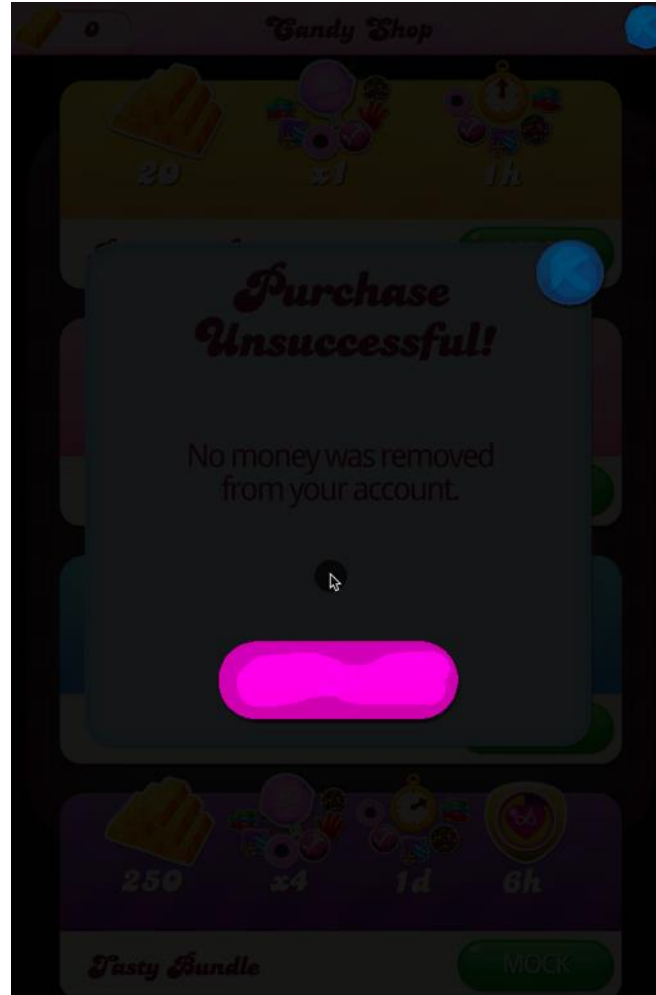
Button detection – AI model training



Button detection – Mask R-CNN

Mask models

- Close button
- Other button

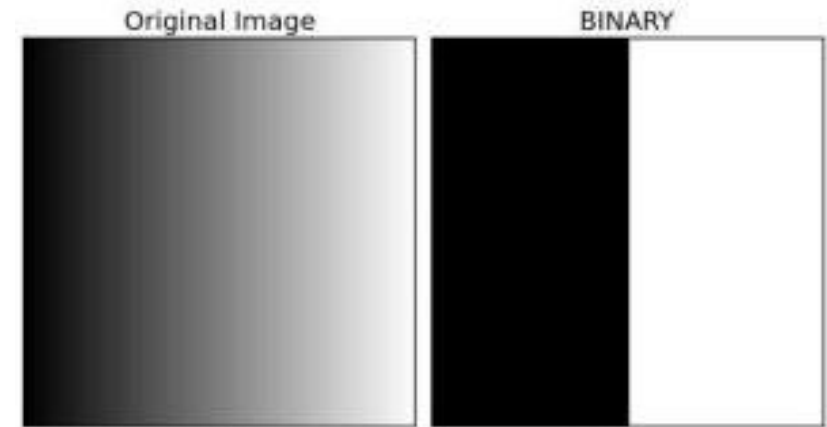


Instance Segmentation

Button detection – image segmentation and thresholding

Color shareholding

- Associate each pixel with black or white according to a threshold(rgb value)



Otsu's Binarization

- Filter to remove noise in an image



Button detection - Result



Similarity detection – Image hash similarity



1. Generate image fingerprint with perceptual hash algorithm (p-hash)



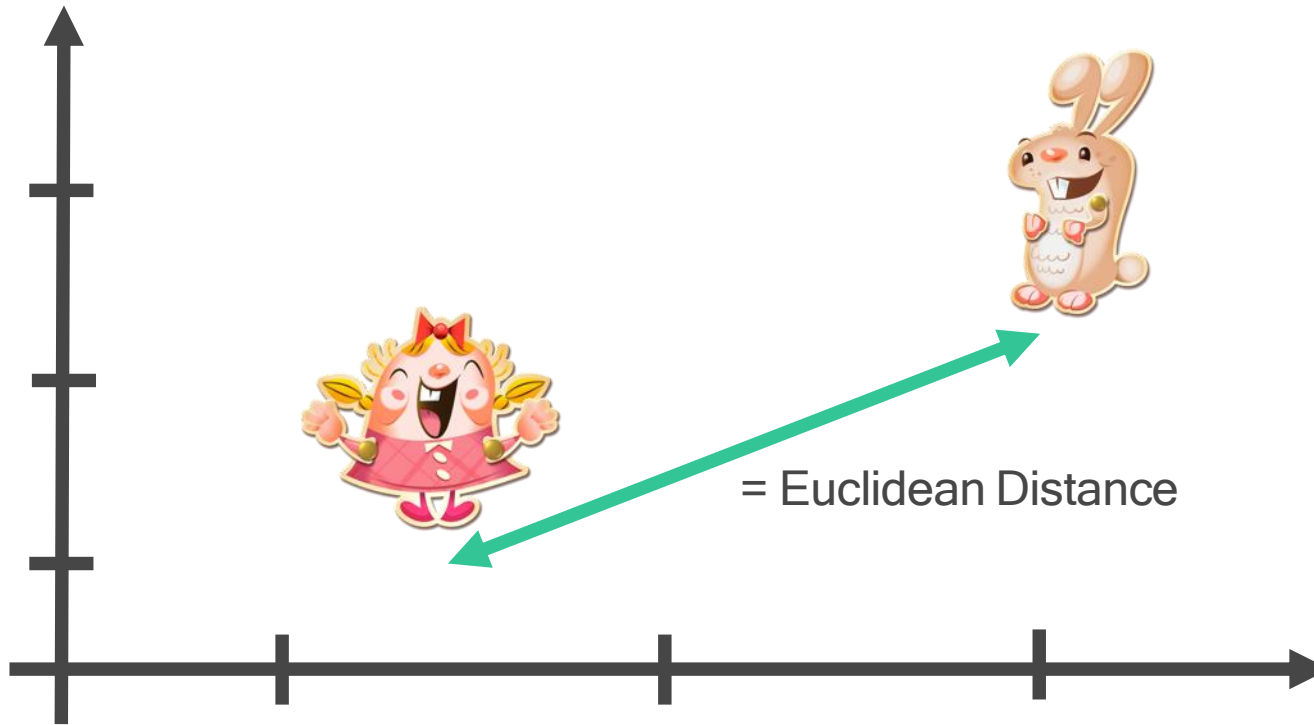
P-hash() = 8a0303f6df3ec8cd



P-hash() = 8c011456ef9eadcc

2. Euclidean distance algorithm used to compute the similarity(distance) of the two hash values.

Similarity detection – Euclidean Distance



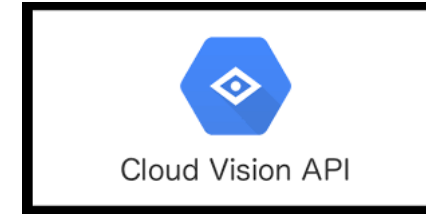
$$\sqrt{\sum_{i=0}^n (x_i - y_i)^2}$$

3. Similarity range 0 = Similar, <6 minor difference, >6 different

4. Compare two images fingerprint, if they are similar by a threshold (<6) then considered same image

Similarity detection – Text similarity

1. Screen parsed by Google vision API for text



2. tfidf vectorizer(word count, !word frequency)used to generate matrix of text input

Text from image 1: “Buy the Gold Bars and give the Piggy Bank”

Text from image 2 : “Piggy Bank!”

Text mining results(tfidf matrixes):

Text Term	Buy	Gold	Bars	give	Piggy	Bank
Text 1	0.3160	0.2248	0.3160	0.3160	0.2248	0.6320
Text2	0	0	0	0	0.7071	0.7071



Cosine similarity = 0.3

Similarity detection – Cosine Similarity

3. **Cosine similarity algorithm** used to calculate distance(0-1) between two vectors and in our case if distance >0.6 text considered similar



$$sim(A, B) = \cos(\theta) = \frac{A \cdot B}{\|A\| \|B\|}$$

Similarity detection – Hash & Text similarity



1



Image Hash similar = similar

2



Image Hash not similar but text similar = similar

3



Image Hash not similar and text not similar = not similar

Similarity detection results



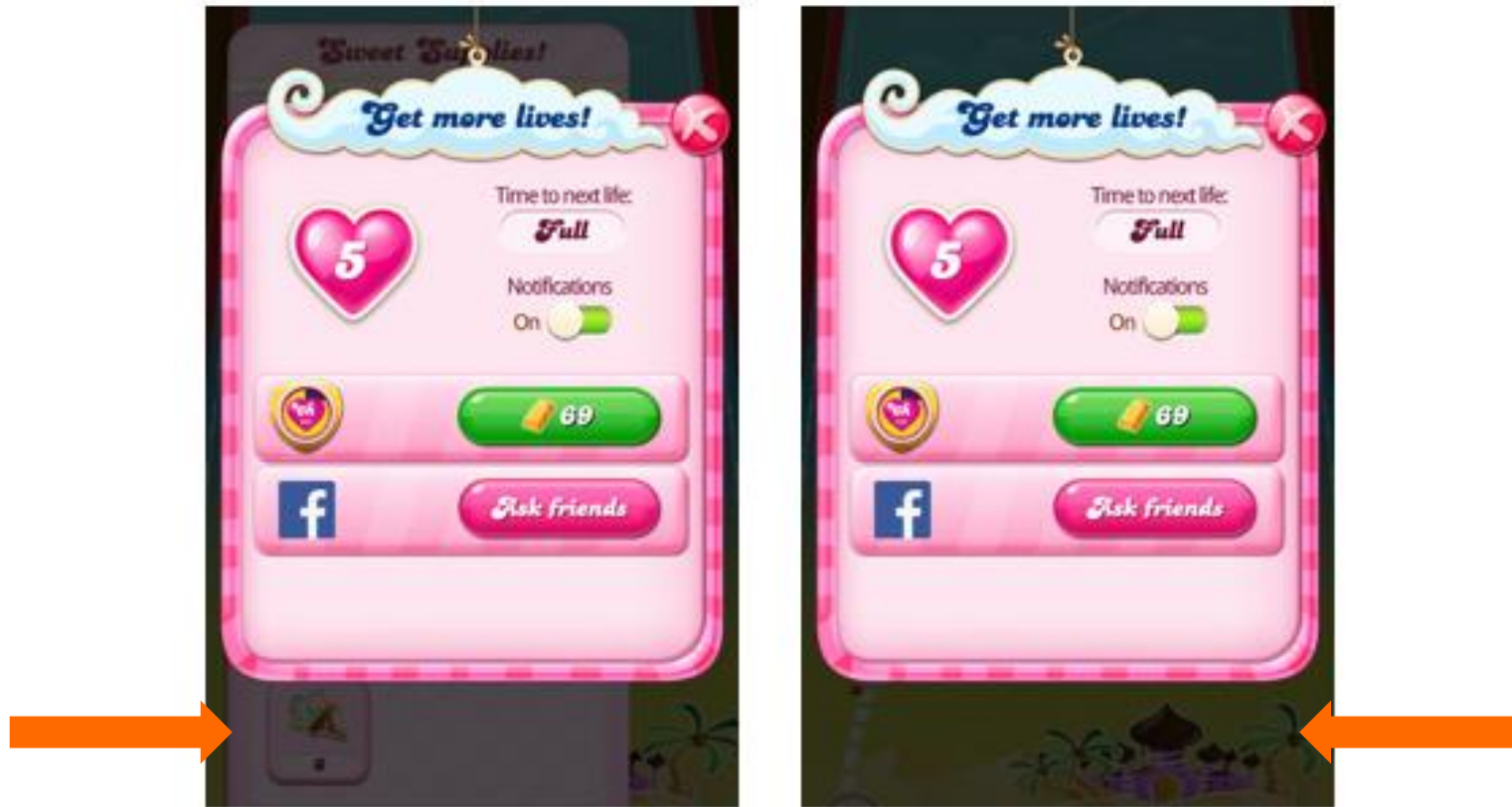
Moving features(animation glitches)

Similarity detection results



Miss-aligned
features(bug)

Similarity detection results



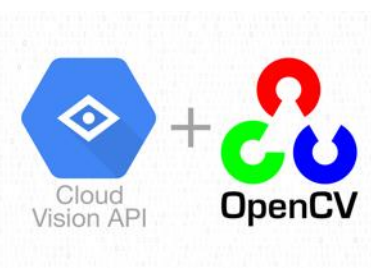
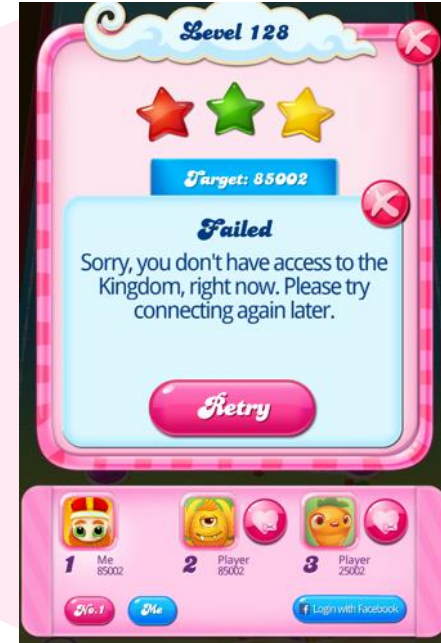
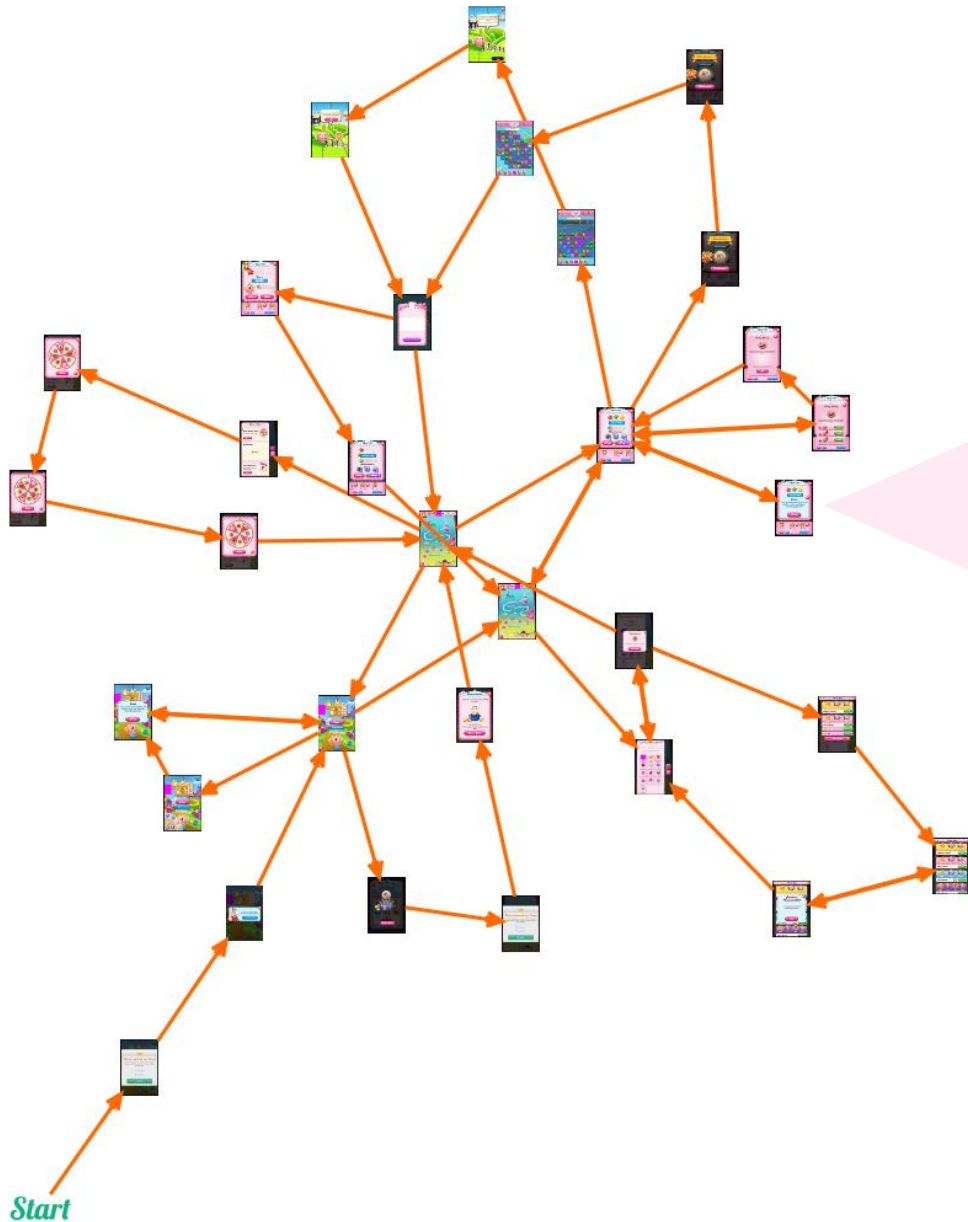
Same screen, different backgrounds(threshold)

Similarity detection results

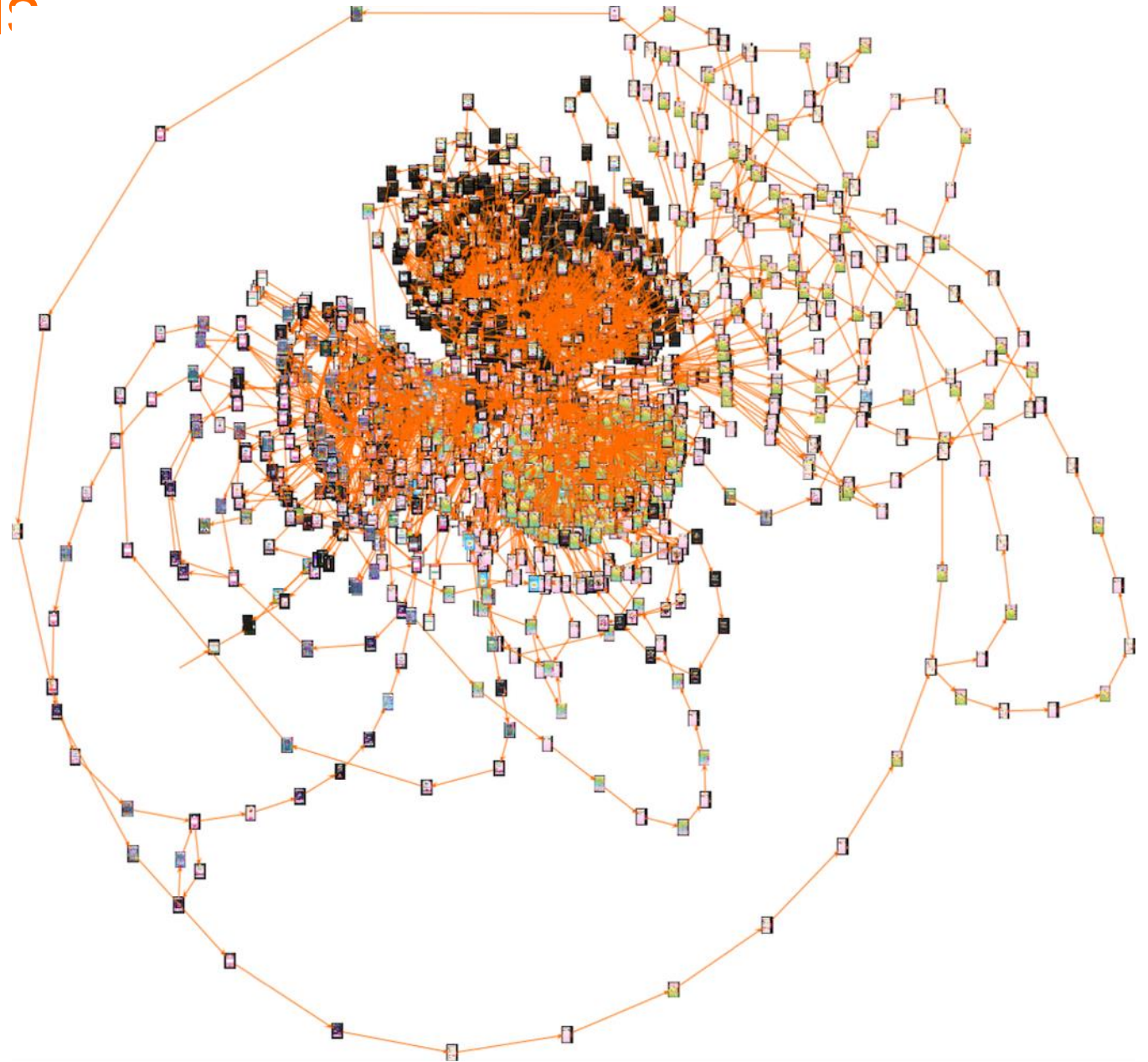


Overlapping menus(new state)

Game Graph



Game Graph +4500 levels



BAIT - Game console commands

- Win/Loose <level>
- Progress <level>
- Unlock <feature>
- Access
<facebook_user_token>



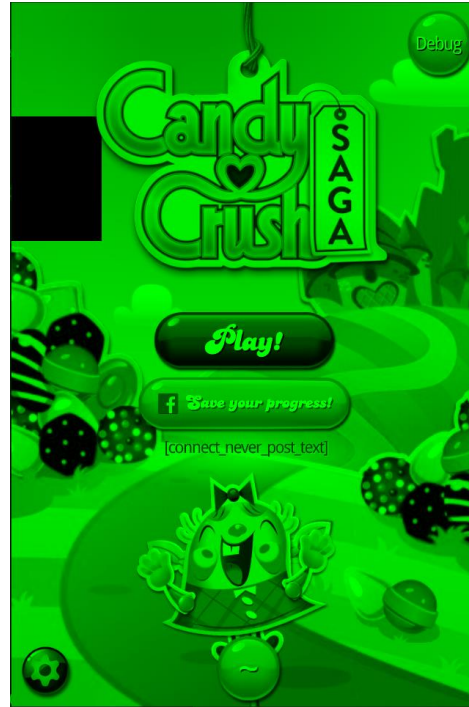
BAIT – Missing texture detection

1



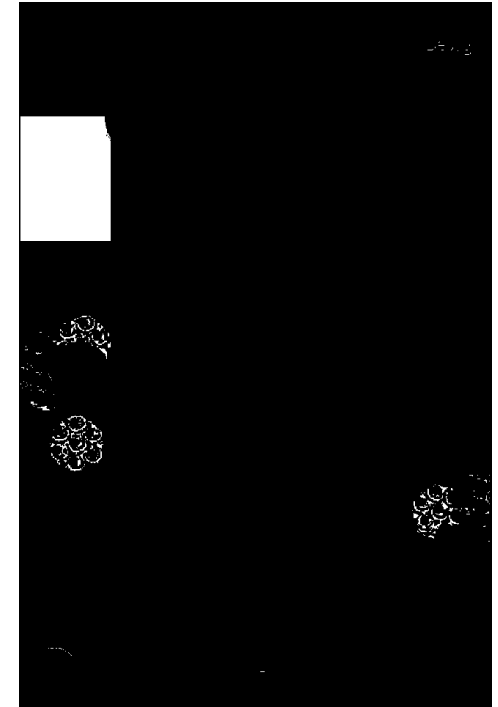
Convert image RGB to only keep Green channel

2



Thresholding - Pixels close to black set to white rest set to black

3



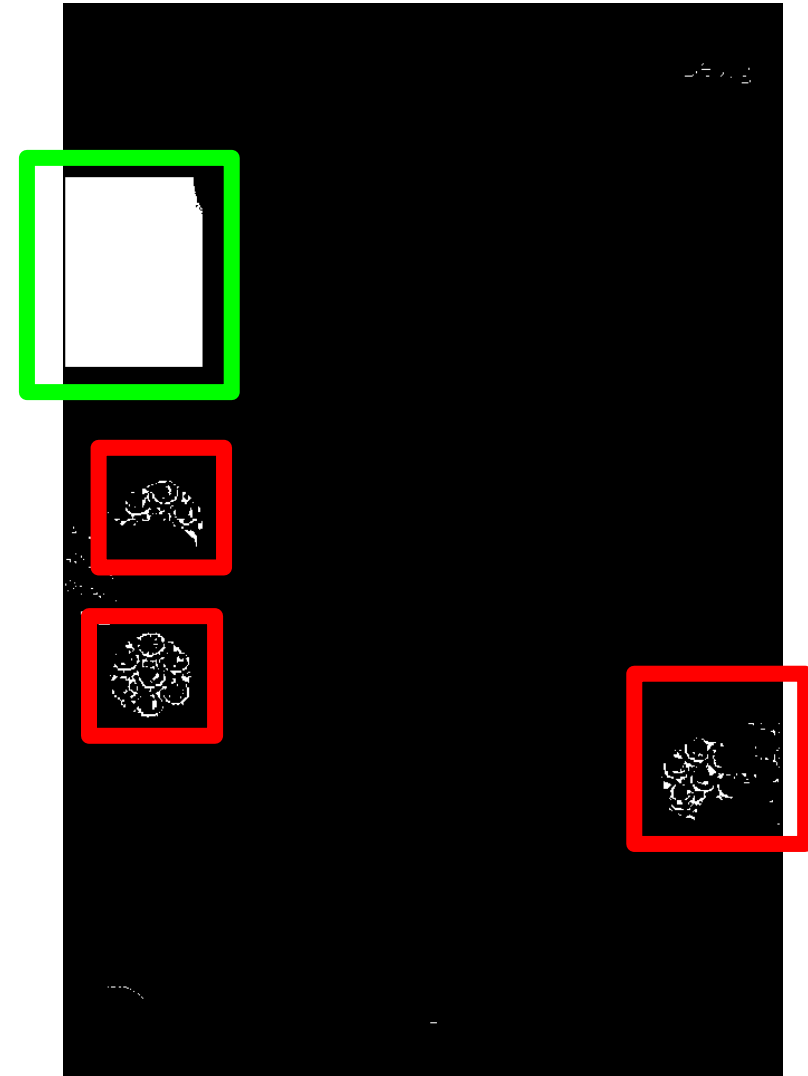
Contour finding algorithm used to find contours

BAIT – Missing texture detection

OpenCV functions used

1. `findContours()` used to find all contours

2. `contourArea()` used to calculate contour area and if below certain threshold it's filtered out



Example - Missing textures



Example - Missing texts



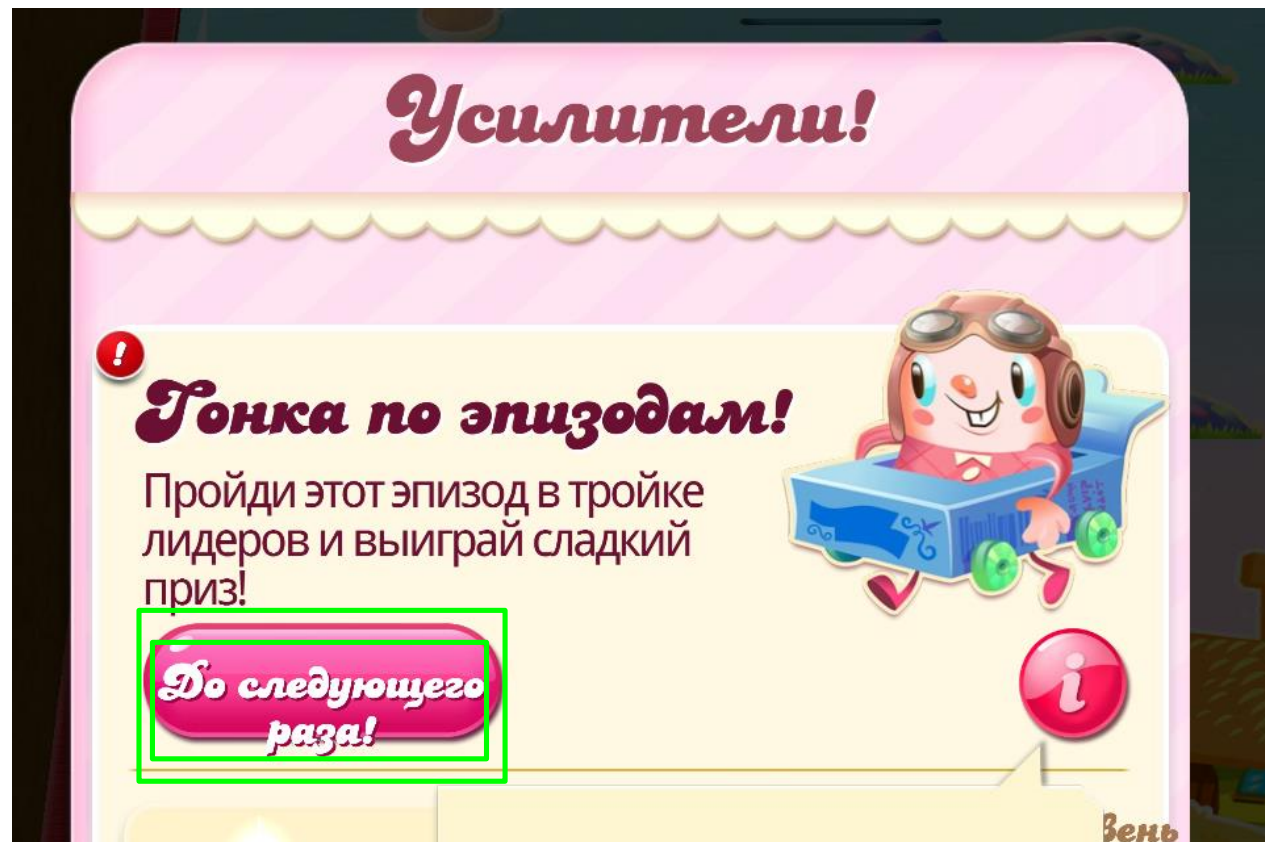
Cloud Vision API



Overlapping objects



Text covered by
buttons

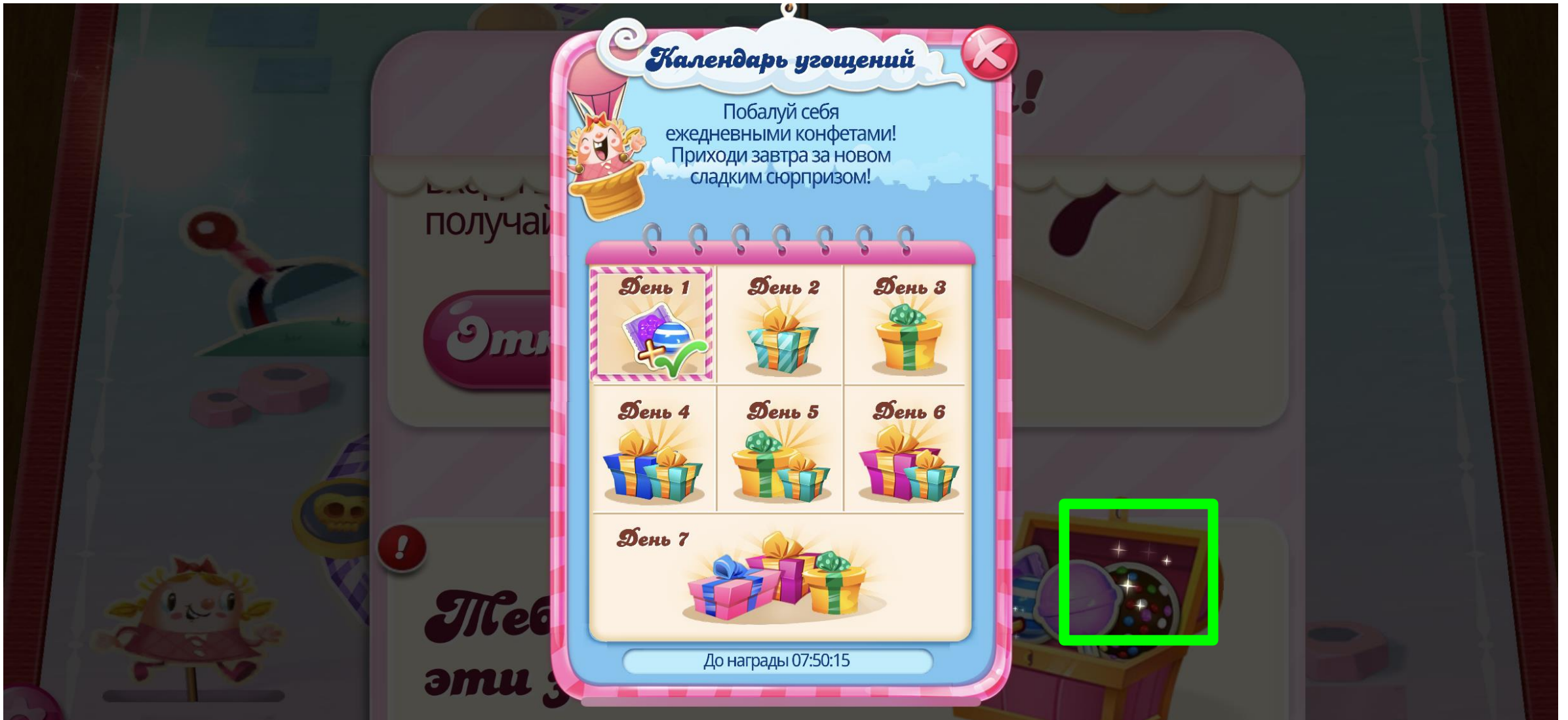


Text does not fit
button

BAIT Quiz – Can you find the bug?



Game Rendering bug



Game Rendering bug – thresholding used for detection



BAIT Requirements



Desktop

GET automation/screenshot/<filename>

GET automation/tap/<x>/<y>

GET automation/level/win

GET automation/fbuser

Mobile

GET automation/level/win

GET automation/fbuser

Click BAIT - Overview

- BAIT frontend
- Run scheduled BAIT jobs
- BAIT statistics



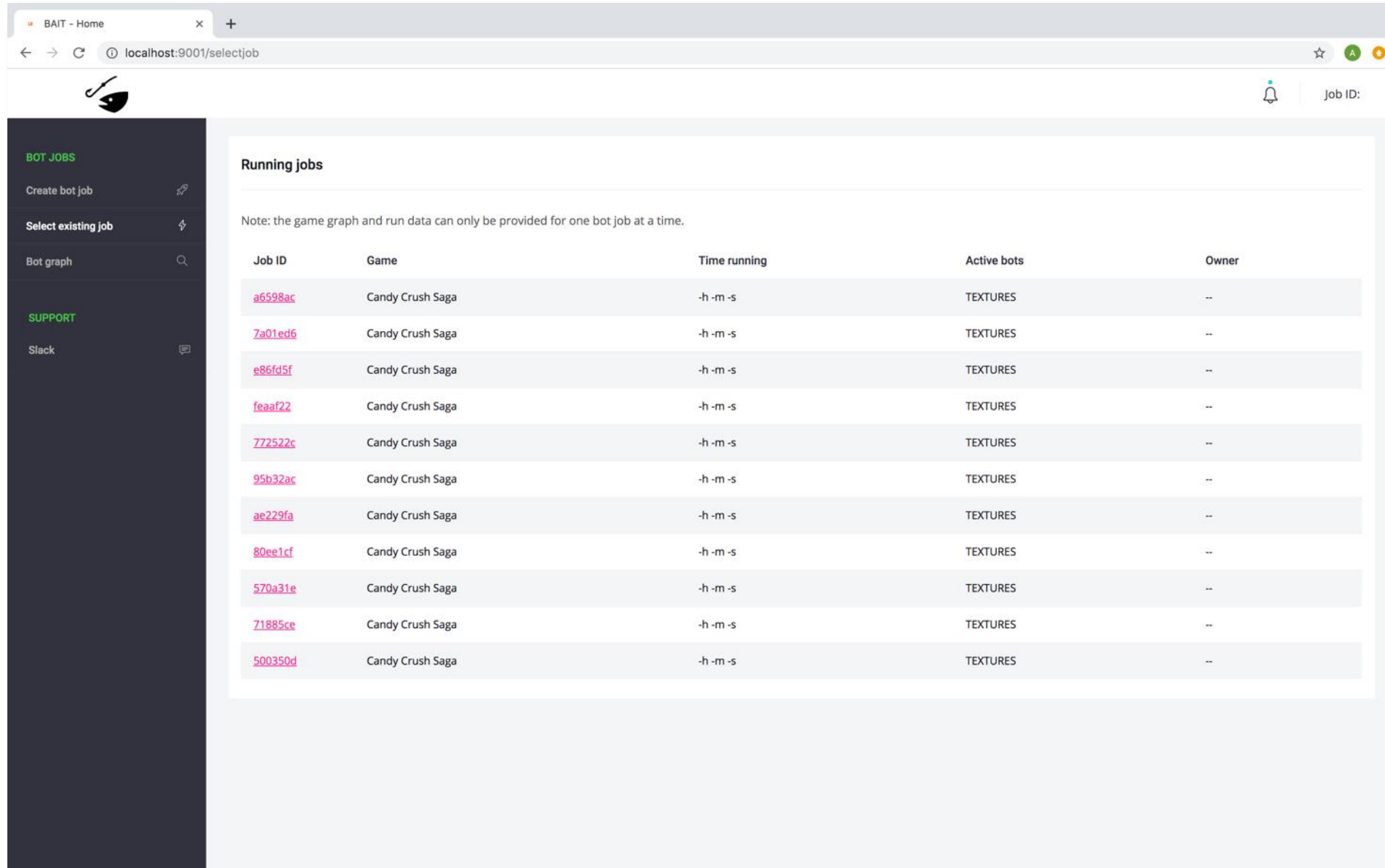
Click BAIT - Dashboard

The screenshot shows a web browser window with the address bar displaying 'localhost:9001'. The page title is 'BAIT - Home'. The dashboard features a dark sidebar on the left with the following menu items: 'BOT JOBS' (highlighted in green), 'Create bot job' (with a plus icon), 'Select existing job' (with a double arrow icon), 'Bot graph' (with a magnifying glass icon), 'SUPPORT' (highlighted in green), and 'Slack' (with a speech bubble icon). The main content area is light gray and contains a 'Welcome to BAIT' section with the text 'Hello! This is BAIT, the bot for AI testing.' Below this are two columns: 'Quickstart' with the text 'If you want to use BAIT for the first time, you need to create a job. This allows you to upload a build you want to test and select which capabilities you want.' and a 'Create a job' button; and 'Follow-a-bot' with the text 'If you previously started a bot job, you can collect results, images and logs from the session pages.' and a 'Find existing job' button. The top right of the dashboard includes a notification bell icon and a 'Job ID:' label.

Click BAIT - Create BAIT job

The screenshot shows a web browser window with the address bar displaying 'localhost:9001/createjob?'. The page features a dark sidebar on the left with navigation options: 'BOT JOBS' (with sub-items 'Create bot job', 'Select existing job', and 'Bot graph') and 'SUPPORT' (with 'Slack'). The main content area is titled 'Requirements' and contains the following text: 'Set up the bot job here. It is optional to enter test capabilities; if you don't, you will only get the game graph.' Below this, there is a 'Game' dropdown menu set to 'Candy Crush Saga'. Under 'Test capabilities', there are two unchecked checkboxes: 'Text detection' and 'Missing textures'. The 'Build' section includes a 'Choose file' button and the text 'No file chosen'. A green 'Submit' button is located at the bottom of the form.

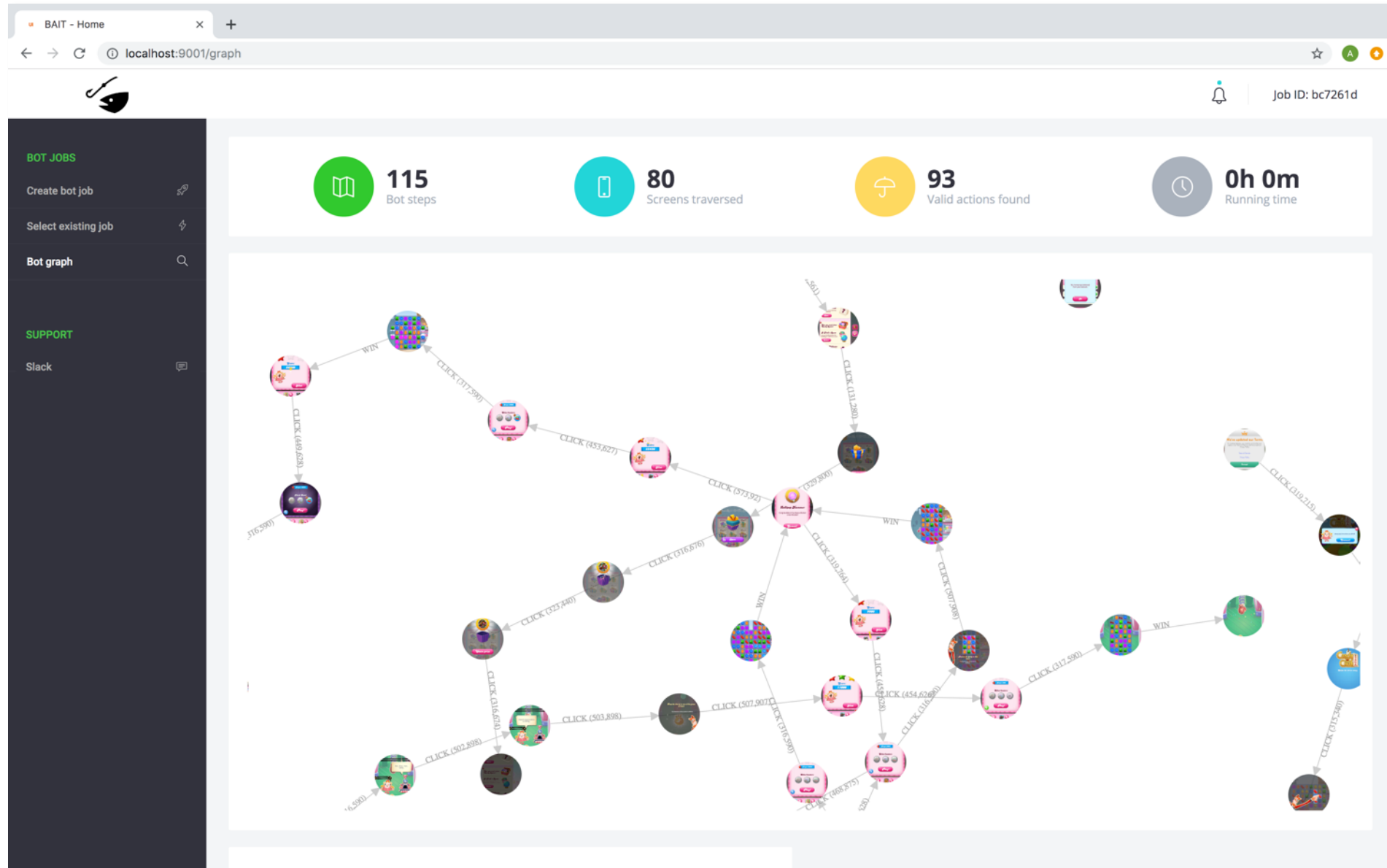
Click BAIT – Bait jobs scheduler



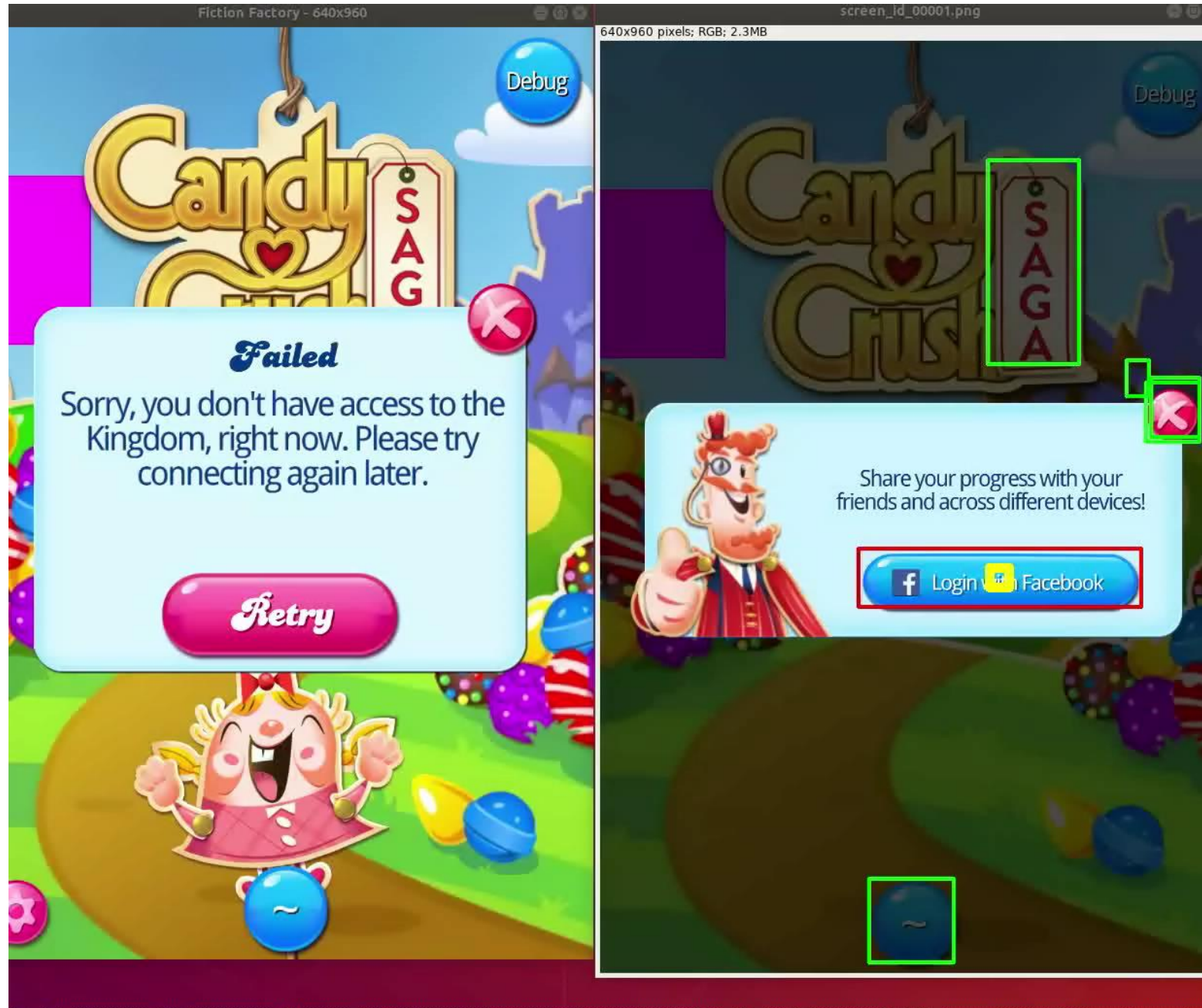
The screenshot shows a web browser window with the address bar displaying "localhost:9001/selectjob". The page title is "BAIT - Home". The main content area is titled "Running jobs" and contains a table of active bot jobs. A note above the table states: "Note: the game graph and run data can only be provided for one bot job at a time." The table has five columns: Job ID, Game, Time running, Active bots, and Owner. All jobs listed are for "Candy Crush Saga" and are running for "-h -m -s" with "TEXTURES" as the active bots and "--" as the owner.

Job ID	Game	Time running	Active bots	Owner
a6598ac	Candy Crush Saga	-h -m -s	TEXTURES	--
7a01ed6	Candy Crush Saga	-h -m -s	TEXTURES	--
e86fd5f	Candy Crush Saga	-h -m -s	TEXTURES	--
feaf22	Candy Crush Saga	-h -m -s	TEXTURES	--
772522c	Candy Crush Saga	-h -m -s	TEXTURES	--
95b32ac	Candy Crush Saga	-h -m -s	TEXTURES	--
ae229fa	Candy Crush Saga	-h -m -s	TEXTURES	--
80ee1cf	Candy Crush Saga	-h -m -s	TEXTURES	--
570a31e	Candy Crush Saga	-h -m -s	TEXTURES	--
71885ce	Candy Crush Saga	-h -m -s	TEXTURES	--
500350d	Candy Crush Saga	-h -m -s	TEXTURES	--

Click BAIT - Statistics



BAIT Demo



Summary - What can BAIT help out with?

- Crashes
- Text bugs
- Missing textures
- Audio errors



Questions?

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king.com/jobs



King

Thank you! :)