JUSTIN: An Audience Participation Game With A Purpose for Collecting Descriptions for Artwork Images

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***Abstract*—This paper presents JUSTIN (Japanese Ukiyo-e Streaming That Improves Narrative), a game system that is designed for collecting descriptive data for artwork images (Japanese Ukiyo-e in this study) in promoting people, especially visually impaired, to come closer to Ukiyo-e artwork by telling them more about it through its descriptions. The proposed game is the first Audience Participation Game With A Purpose (APGWAP), which combines two existing concepts: Audience Participation Games and Game With A Purpose for addressing problems by utilizing human participation on a live streaming platform. The descriptive data obtained from the game can be beneficial in humanity research and in promoting cultural heritage. However, it is noted that the data of most Ukiyo-e images is currently insufficient, sparse or poor in quality. Traditionally, the data created by a limited number of experts in the field, which is commonly very time-consuming and costly. Meanwhile, the system proves to be a powerful tool in exploiting crowd-sourcing for addressing such problems through a solid evidence provided from results of a full-scale experiment in terms of the quality of collected descriptions as well as player experiences.**

***Index Terms*—GWAP, APG, Ukiyo-e, Crowd-sourcing, Game Live Streaming, Game and Interactive Media**

I. Introduction

Image information such as keywords, titles and descriptions has proven to be useful in improving the performance of machine learning systems [1] and the accessibility of visually impaired people [2]. For the former, the text-based metadata information of images can be used to augment training data, while for the latter, such information allows visually impaired people to grasp the content of an image through its description and text-to-speech technologies. However, acquisition of descriptive data for artwork images, which we target in this work, by human experts is time consuming and costly. As a result, there exist only a few small-scale data sets [3], [4]. Methods in existing studies on caption generation for arbitrary images [5] [6] [7] do not perform well for artwork images unless they are enhanced using a sufficient number of targeted image data and their descriptive data, which are however not available yet.

A concept that can be applied to collect descriptions for artwork images is Game With a Purpose (GWAP), which uses games for humans to address problems that computers cannot solve. GWAPs have been successful in many different domains varying from computer vision, natural language processing to web accessibility. In this work, this concept is implemented on a live streaming platform.

With the rise of live streaming platforms such as Twitch and YouTube, audience participation games (APGs) have grown in popularity. An APG is a game live streaming that allows audiences to not only watch but also participate gameplay in part. Although the potential of combining both APG and GWAP concepts for descriptive data collection of artwork images (ukiyo-e in our study) was first described in a two-page vision paper [8] and a two-page survey paper [9], both by our group, the main contributions in this current work are as follow:

- a new concept called audience participation game with a purpose (APGWAP),
- a complete design of our APGWAP, which can be of use as a reference for other purposes, and
- results as well as discussions on description quality and player enjoyment from a conducted full-scale experiment with the proposed APGWAP.

II. Related Work

Many researches have done on Ukiyo-e, a Japanese artwork genre, for promoting it to more and more people. And complementing metadata such as titles, tags and descriptions for most Ukiyo-e images is a crucial task since similar to natural

images, it has many benefits in deep learning research, image retrieval or improving accessibility for the visually impaired, especially in cultural heritage field. However, most of Ukiyo-e images lack their content descriptions and automatic generating descriptions for artwork images is a challenging task for computer.

A. Game With A Purpose (GWAP)

Meanwhile, GWAP, a serious game type proposed by von Ahn et al. [10], has successful proved its contribution to several applications like data annotation in natural language processing (NLP) [11] [12], image labeling in computer vision and web accessibility. The first implementation of GWAP was the ESP game created by von Ahn and Dabbish [13], with a purpose of collecting meaningful and proper labels for images on the Web, which was shown to be successful in terms of players enjoyment and the number of valuable meaningful labels obtained, two main goals of GWAP. It seemed, however, that there was a disadvantage of the game was stated out by Steinmayr et al. [14] that is the obtained labels are generic and not specific enough to differentiate similar images. As a solution, Steinmayr et al. proposed Karido, a game designed for collecting specific labels for artwork images and Harris et al. [15] introduced ClueMeIn for obtaining detailed labels for arbitrary images. Different from above games, which aimed for keywords collection, the Phetch game by von Ahn et al. [16] aimed for descriptions for arbitrary images, in which the game copes with the problem of attaching descriptive sentences to images on the web that are beneficial in web accessibility. In these games, however, it is difficult to reach a massive number of players and keep them stay long since the players have to concentrate in playing them, without doing anything else. We believe that beside playing game, players likely to chat with many others socially on different topics by having fun during some break time of the game or talk about their score, etc., it would be interesting to build a system where players can do these activities.

B. Audience Participation Game (APG)

APG can come in rescue for the problem above. APG is a kind of games that empowers live audiences on a live streaming platforms by allowing them to control the game play through their messages sent in chat room area [17]. The most well-known example of APG is Twitch Plays Pokmon created by Ramirez et al. [18], a result of a crowdsourced attempt to play the Pokmon video game by executing commands sent by audiences through the channels chat room. Another example of APG is Choice Chamber, a real-time, procedurally generated game, where live audiences constantly send commands to evolve the game in real time, from choosing enemies, power up abilities of the main character or changing the game rules while the streamer control the main character in the game. From these games, it is seen that APG has blurred the line between audiences and players in a meaningful way [17]. However, as pointed out by our previous work [9], the purpose of APG was just for fun or to promote social interactions between audiences and streamers or audiences themselves, not for obtaining valuable data as a side effect through participation of audiences in the games. Therefore, we believe that combining a live-streaming APG and GWAP as a new game concept APGWAP can be a perfect choice to make a GWAP more interesting to play while containing a purpose of doing valuable tasks that benefits real world applications.

III. JUSTIN: The Game Design

We proposed a novel game named JUSTIN which stands for Japanese Ukiyo-e Streaming That Improves Narrative, a live streaming video game which implements the game concept APGWAP on a channel on the Twitch.tv. The game is designed for collecting good quality descriptions for Ukiyo-e artwork images through chat commands sent by audiences through the channels chat room.

A. Rules of JUSTIN

In JUSTIN game live-streaming on Twitch, players will play the game through the chat room area by sending messages in predefined formats to control the game play. Each round of the game has three sessions consecutively: describing, voting and resulting session. There are two roles: describers and voters corresponding to the first two sessions: describing and voting. An audience who wants to participate in the game can choose to become one of the roles.

In describing session, a group of describers can describe up to three images through chat messages in a predefined format imageID:description. This session ends in 80 seconds. After this period of time, the game turns to the voting session and audiences who are not the describers in previous session can be voters.

In the voting session, the system will show a list of descriptions, which are obtained from the describing session and previous winning descriptions in previous rounds of each image. And a group of voters can vote for the best suit description to the corresponding image in a predefined format descriptionID in 30 seconds. Each voter can only vote for one description in the list.

Defining describing and voting formats are important to distinguish them from other audiences messages and within themselves. After voting session is the resulting session. The game will show results of the game including which description wins for each image, who gets points, who gets penalized, etc. In which, the winning description of an image is the one which get highest number of votes among the list of descriptions of the image from voters.

B. GUI Design

In our previous work [8], we designed our game as a mini game which show along with a main game, AngryIce. However, due to the limit of screen size for live streaming on Twitch, which includes the size of three Ukiyo-e images shown were small and the images could not be seen clearly. Therefore, we redesigned our game and implemented it as a main game and removed AngryIce out of our game part.

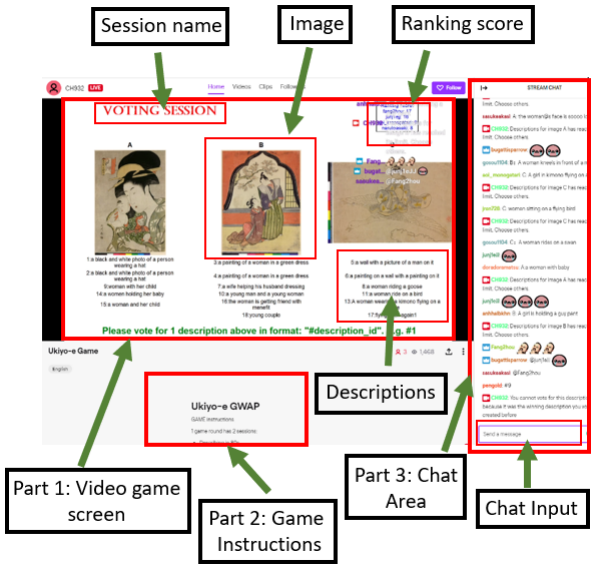

Fig. 1. JUSTIN on Twitch

Our new game design includes three main parts (Fig. 1): the first part is the video game screen which includes three Ukiyo-e images with corresponding their id (A, B, C), notification for asking audiences to describe or vote in each describing/voting session or showing results in resulting session, session name, a list of descriptions in voting session corresponding to each image and ranking score. Second, the chat area for showing messages from audiences who participate in the game and chatting and it includes chat input for them can type and send messages. The third part is game instructions which shows verbally the rules of the game and how to play it.

C. Implementation

The game was implemented using Python programming language and is live streaming on Twitch at ch932 channel[1] using StreamLabs Open Broadcaster Software (OBS) [19], a popular streaming software built on Electron and OBS for streaming videos on Twitch.tv, Youtube Gaming and other live streaming platforms. For graphic user interface (GUI), we used Tkinter, a standard python GUI library for creating GUI applications. For better interacting with audiences, we created a channels chatbot using Twitch API.

In the voting session, along with descriptions created by describers in describing session, the game also show two descriptions, which are automatically generated by Pythia [6] [7], a deep learning framework including image captioning model, for each image. The two generated descriptions for each image are for making the game active in the case of no description created by describers or for proving more choices to voters to vote.

[1]https://www.twitch.tv/ch932

D. Reward and Penalty Mechanisms

The system introduces reward and penalty mechanisms as giving positive/minus scores to both participants and descriptions to improve quality of winning descriptions collected, encourage players to well play and prevent cheating while players play the game. An images in the game can be shown several times and its winning descriptions, which accumulated from each rounds its image shown, also be shown during voting session for collecting good quality descriptions.

In reward mechanism, player p_i^* as describer or voter, who create or vote the winning description d_{ij}^* for image j, will accumulate positive points following the equation below:

$$Score(p_i^*) \mathrel{+}= \frac{1}{M}\sum_{j=1}^{M}\frac{v_{ij}^*}{v_j} \tag{1}$$

Where M is the number of images shown by the game in each round (three in this study), v_{ij}^* is the number of votes given to d_{ij}^* by voters, v_j is the total votes from all descriptions of image j. And the winning description d_{ij}^* also has score and its score is defined as follow:

$$Score(d_{ij}^*) \mathrel{+}= \frac{v_{ij}^*}{v_j} \tag{2}$$

Both $Score(p_i^*)$ and $Score(d_{ij}^*)$ are initialized as 0 at the beginning. The reward mechanism is for encouraging players to play game while penalty mechanism is for preventing cheating from players, helping to improve the quality of descriptions for images by removing the bad winning descriptions and selecting the good ones.

Penalty mechanism is activated in the round when an image, which has been used in the previous rounds, now is showing in this round. The mechanism is applied to the descriptions which won for the image j in previous rounds called the former winning descriptions d_{sj} and to the describer and voter p_s who created or voted d_{sj}. In more detail is:

If the d_{sj} wins again at this round, d_{sj} will be considered as the winning description and its score will be defined as in equation (2). This will assert that the description keep winning in many rounds are good description and should be final description when its score reach an upper bound threshold $b = 2.0$. However, there will be no reward for p_s by the win of d_{sj} with a purpose of ensuring players are not relying too much on their first winning description to get score but also try his or her best to create or vote new descriptions.

Otherwise, If d_{sj} does not win at the current round or number of votes on d_{sj} is zero, the system will consider three cases in whether to apply penalty or not:

- The first case is if the number of votes is smaller than M and there is no one votes for d_{sj}, there will be no penalty applied to p_s and d_{sj}. This is because there is not enough of number of votes for determining d_{sj} is bad since a voter can only vote for one description and he or she might not choose d_{sj} but the one of an image he or she prefer.

- The penalty is also not applied in the second case which is when p_s created an another description for the image j and it wins and get reward as equation (1) and (2) applied to p_s and d_{sj} respectively. This case is for giving p_s a chance to improve his or her former winning descriptions by creating other descriptions which are likely to win in this round if he or she think the former winning ones are not good enough for the corresponding images. Hence, the quality of the description of an image theoretically will be improved every time the image appears on the game screen.
- If these are not the case, the score of p_s and the description d_{sj} will be decreased following the penalty equation (3) and (4), respectively as follow:

$$Score(p_s) -= u_j(1 - \frac{v_{sj}}{v^*_{ij}}) \;\; with\, i \neq s \qquad (3)$$

$$Score(d_{sj}) -= u_j(1 - \frac{v_{sj}}{v^*_{ij}}) \;\; with\, i \neq s \qquad (4)$$

Where $u_j = \frac{v_j}{v}$ presents how popular of image j at the current round or how preferable of image j compared to others by voters, v is the total votes on all descriptions of all images, v_{sj} is the number of votes on d_{sj}. When the score of d_{sj} is below the lower bound threshold $a = 0.3$, it will be removed from the list of descriptions of the corresponding image in the voting session. This helps to remove the bad descriptions which used to win in previous rounds. The penalty on players will prevent describers and voters from intentionally creating poor descriptions and not seriously making votes, respectively.

The reward and penalty mechanisms can be illustrated through an example in figure 2.

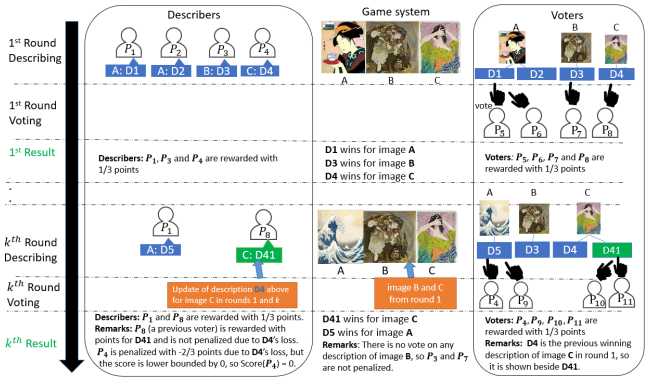

Fig. 2. Game mechanism example

E. Description Quality Assurance

To ensure a winning description is bad or good for an image, we set thresholds for score of the description after the image is shown the second time. As mentioned in scoring section, if the score of the description reach the upper bound threshold: $b = 2.0$, the system will stop showing the image, and the description will be the final description for the image. If the score of the description is lower than a lower bound threshold: $a = 0.3$, the description will be removed from the list of descriptions which are shown for its image in voting session.

Fig. 3. Image information: Keywords, expert description and non-expert description

IV. Experiment and Result

The experiment was conducted to evaluate in terms of descriptions quality and player experience. The full-scale experiments show that the quality of descriptions obtained are good enough and people are enjoy playing our game, they were having fun with it.

A. Description Quality Evaluation

For descriptions quality evaluation, we conducted an experiment that simulates our game. The experiment was divided to three stages: describing, voting and evaluation. For describing stage, we asked twenty-four participants (all are master students, out of which five students are female), divided to four equal groups, each group describe five images (twenty images in total). For voting stage, we asked nineteen participants (five masters, ten bachelors, two high-school and two doctors, out of which two students are female) to select the best description from the list of descriptions obtained from the describing stage for each image. For evaluation stage, due to lacking people volunteering, we asked the twenty-four participants in the describing stage to join the experiment. The experiments of each stage were set up on different days.

The evaluation in the evaluation stage is on the correctness and sufficiency of the descriptions (non-expert descriptions, each non-expert description is the best description which has the highest number of votes among others obtained from the voting stage of an image) created by general people (the twenty-four participants in the describing stage) compared to keywords and expert descriptions (which were created by experts) in term of targeting to non-expert people. To this extent, we assigned the twenty-four participants to three of conditions: keywords, experts descriptions and non-experts descriptions. The twenty-four participants were divided to two equal groups and each group answers ten questions of each condition (60 questions in total, 30 questions for each group) to make sure participants in each group have not seen the

images in the describing stage before. Each participant was asked to choose one image from other similar images based on images information from the three mentioned conditions. Twenty images, which are used from describing and voting stage, are used in this stage. For each image we combined with four other similar images to it. We use doc2vec, a deep learning model for converting phrase, sentence or document to a vector proposed by Le et al. [20], to calculate the images similarity based on their expert descriptions.

For non-expert descriptions condition, participants were able to select correct image 92.9% of the time. For expert descriptions condition, 75% of the time. And for keywords condition, only 50.7% of the time. The results show that, descriptions created by non-experts are better, more descriptive than ones by experts or keywords only (two examples in fig. 3 to represent this). Our first experiment result show that descriptions for artwork images created by normal people can be as good as expert descriptions in term of quality and information convoyed of the images for general people or data training in computer vision tasks.

B. Player Experience Evaluation

For evaluating the enjoyment of players while playing game, we conducted a control experiment with twenty-five participants (three bachelors, twenty-two masters, out of which five females) playing our JUSTIN game on Twitch.tv in eighteen minutes. In this case, we only used twelve images which are from british museum[2] to ensure most of the images to be randomly displayed at least three time for each during the experiment time so we can evaluate the reward and penalty mechanisms and the improvement of descriptions quality over time as well (see the Discussion section below).

First, each participant learns how to play JUSTIN game through a demonstration played by four volunteering players who have played the game before. After twenty minutes of playing game, the participants are asked to answer a questionnaire on their experience on JUSTIN game. Our questionnaire is based on GUESS questionnaire which is from a study on the measurement of video game satisfaction based on nine key factors by Phan et al. [21]. Because our game has no story and sound/music at the time of the experiment so in our questionnaire, the factor 2 (Narratives) and factor 6 (Audio Aesthetic) were excluded. Each of the remaining seven factors has two questions and each question is evaluated in a 5 point Likert scale from 1 (Strongly disagreed) to 5 (Strongly agreed). All questions of seven factors are shown in Table I. A total of fourteen GUESS questions were displayed in random order to each participant who answers the questionnaire.

The result can be seen at blue chart in fig. 4. As we can see, all factors got points above 3 in average (neutral and agree). And for social connectivity factor, the point is nearly 4 (agree) means most participants are enjoying in socially. For visual aesthetics factor, the average point of the two questions is 3 (neutral), means that participants have neutral feeling about the graphic of the game since the graphic of the game is not good enough. Hence, it needs to be improved in future work. For factor 5, creative freedom, the average point is 3.4, means people are creative in describing images as the game requires a lot of thinking in describing. And people are enjoying in playing game as shown in factor 4: enjoyment which gets point of 3.44.

[2]https://research.britishmuseum.org/research/collection$_online/search.aspx?searchText=ukiyo-e$

TABLE I
GUESS QUESTIONS

Factors	Questions
1	I think it is easy to learn how to play the game.
1	I find the controls of the game to be straightforward.
3	I feel detached from the outside world while playing the game.
3	I do not care to check events that are happening in the real world during the game.
4	I think the game is fun.
4	I enjoy playing the game.
5	I feel the game allows me to be imaginative
5	I feel creative while playing the game.
7	I am in suspense about whether I will succeed in the game.
7	I feel successful when I overcome the obstacles in the game.
8	I find the game supports social interaction (e.g., chat) between players.
8	I like to play this game with other players.
9	I enjoy the games graphics.
9	I think the graphics of the game fit the mood or style of the game.

Factors: (1) Usability/Playability, (3) Play Engrossment, (4) Enjoyment, (5) Creative Freedom, (7) Personal Gratification, (8) Social Connectivity, (9) Visual Aesthetics

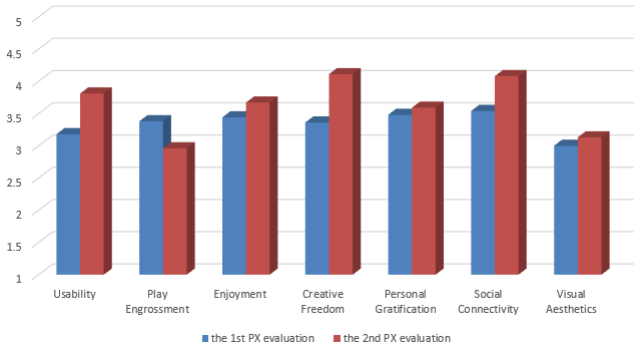

Fig. 4. Result of each satisfaction factor on JUSTIN game in the first control experiment and the second control experiment after publicizing

Beside GUESS questions, we also asked for comments on the game and most of participants gave very valuable comments helping to improve the game. Based on that, we did improve on GUI by increasing the voting time, added background music, etc. and we have publicized the game online since February 16, 2020. During one month of publicizing, we also conducted another control experiment at Bangkok University with twenty-one participants who are first year bachelor and we have received several feedback on the game through the same questionnaire we used in the control experiment above and valuable descriptions for Ukiyo-

e images. And we can see, most of factors as red chart in fig. 4 have its point increased compared to the ones (blue chart) in the first control experiment.

V. Discussion and Conclusions

A. Discussion

In this section, we would like to discuss some interesting cases about scoring mechanism and improvement of descriptions quality through the game rounds. We can look at some examples obtained from our experiment in figure 5. On the left image in the figure 4, the description man and woman in European clothes won two times in two rounds and gained absolute score 1.0 for each round, two points in total. And this description is a final description for image 1 as its score reached upper bound threshold 2.0. Hence, the image 1 was qualified to not being shown again by the game system. And we can see the first description man and woman in European clothes of image 1 has better quality compared to its another winning description a man and a woman with score of 0.66.

For image 2, this is an interesting case that proves our penalty mechanism works well on helping to improve the quality of description by increasing the score of good description and decreasing the score of bad/not good description for an image every time the image shown. The image was displayed five time in total. The description A woman riding a goose won in the first two rounds but then there was a better description A woman wearing a kimono flying on a goose kept winning in the next two rounds and got total score of 1.0. In the last round, a new description "Flying duck again1" won but with low score 0.4. We believe that if the game continue to be played, this new description will not win again as it is not a good description compared to other winning description of the image. Meanwhile, the description A woman riding on goose kept losing and got penalty and finally got score of 0.3. From

Time flow	Winning descriptions	Score
1st	A man and a woman	1.0
2nd	Man and woman in European clothes	1.0
	A man and a woman	0.8 ↓
3rd	Man and woman in European clothes	2.0 ↑
	A man and a woman	0.66 ↓

Time flow	Winning descriptions	Score
1st	A woman riding a goose	0.4
2nd	A woman riding a goose	0.7 ↑
3rd	A woman wearing a kimono flying on a goose	1
	A woman riding a goose	0.5 ↓
4th	A woman wearing a kimono flying on a goose	1.3 ↑
	A woman riding a goose	0.4 ↓
5th	Flying duck again1	0.4
	A woman wearing a kimono flying on a goose	1.0 ↓
	A woman riding a goose	0.3 ↓

Fig. 5. The improvement of winning description of an image through game rounds

these interesting cases and the scoring mechanism presented above, we believe that if the game is kept playing for a period of time, we will collect a good quality description for each Ukiyo-e image.

B. Conclusion and Future Works

We presented a novel live-streaming game, named JUSTIN, that implements a new game design concept Audience Participation Games With a Purpose (APGWAP) for collecting descriptive sentences for Ukiyo-e images through chatting on a game live streaming platform. Descriptions of Ukiyo-e images collected from this system can be further used in future works, e.g., a module recommending Ukiyo-e images as a video game background to a group of audiences watching live streaming. Or used in applications for improving accessibility for visually impaired people in helping reducing inequality. Our pilot studies offer an evidence that APGWAP can be exploited as a novel effective way for data collection in humanities research; our JUSTIN is successful example of APGWAP for future researches to follow.

Based on the valuable comments we get at the second experiment at Bangkok University, we will do as follow to improve the game in the future work:

- Support more languages such as Japanese, Thai, Vietnamese so non-english speaking can play as well.
- Add functions to the chat bot to make it more interactive. For example, do cheering after players win or create or vote a description to encourage them
- Improve graphics by using Unity to develop the game
- Add auto words correction so when players type wrong word or have typos, the system to automatically correct itself.

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