Report on the Second NLG Challenge on Generating Instructions in Virtual Environments (GIVE-2)

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Abstract

We describe the second installment of the Challenge on Generating Instructions in Virtual Environments (GIVE-2), a shared task for the NLG community which took place in 2009-10. We evaluated seven NLG systems by connecting them to 1825 users over the Internet, and report the results of this evaluation in terms of objective and subjective measures.

1 Introduction

This paper reports on the methodology and results of the Second Challenge on Generating Instructions in Virtual Environments (GIVE-2), which we ran from August 2009 to May 2010. GIVE is a shared task for the NLG community which we ran for the first time in 2008-09 (Koller et al., 2010). An NLG system in this task must generate instructions which guide a human user in solving a treasure-hunt task in a virtual 3D world, in real time. For the evaluation, we connect these NLG systems to users over the Internet, which makes it possible to collect large amounts of evaluation data cheaply.

While the GIVE-1 challenge was a success, in that it evaluated five NLG systems on data from 1143 game runs in the virtual environments, it was limited in that users could only move and turn in discrete steps in the virtual environments. This made the NLG task easier than intended; one of the best-performing GIVE-1 systems generated instructions of the form "move three steps forward". The primary change in GIVE-2 compared to GIVE-1 is that users could now move and turn freely, which makes expressions like "three steps" meaningless, and makes it hard to predict the precise effect of instructing a user to "turn left".

We evaluated seven NLG systems from six institutions in GIVE-2 over a period of three months from February to May 2010. During this time, we collected 1825 games that were played by users from 39 countries, which is an increase of over 50% over the data we collected in GIVE-1. We evaluated each system both on objective measures (success rate, completion time, etc.) and subjective measures which were collected by asking the users to fill in a questionnaire. We completely revised the questionnaire for the second challenge, which now consists of relatively fine-grained questions that can be combined into more high-level groups for reporting. We also introduced several new objective measures, including the point in the game in which users lost or cancelled, and an experimental "back-to-base" task intended to measure how much users learned about the virtual world while interacting with the NLG system.

Plan of the paper. The paper is structured as follows. In Section 2, we describe and motivate the GIVE-2 Challenge. In section 3, we describe the evaluation method and infrastructure. Section 4 reports on the evaluation results. Finally, we conclude and discuss future work in Section 5.

2 The GIVE Challenge

GIVE-2 is the second installment of the GIVE Challenge ("Generating Instructions in Virtual Environments"), which we ran for the first time in 2008-09. In the GIVE scenario, subjects try to solve a treasure hunt in a virtual 3D world that they have not seen before. The computer has a complete symbolic representation of the virtual world. The challenge for the NLG system is to generate, in real time, natural-language instructions that will guide the users to the successful completion of their task.

Users participating in the GIVE evaluation start the 3D game from our website at `www.give-challenge.org`. They then see a 3D

Figure 1: What the user sees when playing with the GIVE Challenge.

game window as in Fig. 1, which displays instructions and allows them to move around in the world and manipulate objects. The first room is a tutorial room where users learn how to interact with the system; they then enter one of three evaluation worlds, where instructions for solving the treasure hunt are generated by an NLG system. Users can either finish a game successfully, lose it by triggering an alarm, or cancel the game. This result is stored in a database for later analysis, along with a complete log of the game.

In each game world we used in GIVE-2, players must pick up a trophy, which is in a wall safe behind a picture. In order to access the trophy, they must first push a button to move the picture to the side, and then push another sequence of buttons to open the safe. One floor tile is alarmed, and players lose the game if they step on this tile without deactivating the alarm first. There are also a number of distractor buttons which either do nothing when pressed or set off an alarm. These distractor buttons are intended to make the game harder and, more importantly, to require appropriate reference to objects in the game world. Finally, game worlds contained a number of objects such as chairs and flowers that did not bear on the task, but were available for use as landmarks in spatial descriptions generated by the NLG systems.

The crucial difference between this task and the (very similar) GIVE-1 task was that in GIVE-2, players could move and turn freely in the virtual world. This is in contrast to GIVE-1, where players could only turn by 90 degree increments, and jump forward and backward by discrete steps. This feature of the way the game controls were set up made it possible for some systems to do very well in GIVE-1 with only minimal intelligence, using exclusively instructions such as "turn right" and "move three steps forward". Such instructions are unrealistic – they could not be carried over to instruction-giving in the real world –, and our aim was to make GIVE harder for systems that relied on them.

3 Method

Following the approach from the GIVE-1 Challenge (Koller et al., 2010), we connected the NLG systems to users over the Internet. In each game run, one user and one NLG system were paired up, with the system trying to guide the user to success in a specific game world.

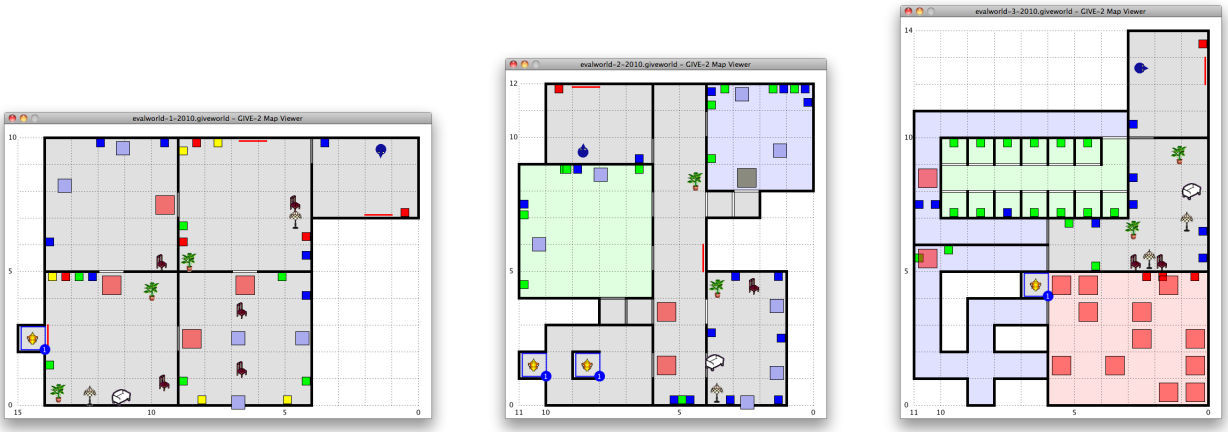
3.1 Software infrastructure

We adapted the GIVE-1 software to the GIVE-2 setting. The GIVE software infrastructure (Koller et al., 2009a) consists of three different modules: The *client*, which is the program which the user runs on their machine to interact with the virtual world (see Fig. 1); a collection of *NLG servers*, which generate instructions in real-time and send them to the client; and a *matchmaker*, which chooses a random NLG server and virtual world for each incoming connection from a client and stores the game results in a database.

The most visible change compared to GIVE-1 was to modify the client so it permitted free movement in the virtual world. This change further necessitated a number of modifications to the internal representation of the world. To support the development of virtual worlds for GIVE, we changed the file format for world descriptions to be much more readable, and provided an automatic tool for displaying virtual worlds graphically (see the screenshots in Fig. 2).

3.2 Recruiting subjects

Participants were recruited using email distribution lists and press releases posted on the Internet and in traditional newspapers. We further advertised GIVE at the Cebit computer expo as part of the Saarland University booth. Recruiting anonymous experimental subjects over the Internet carries known risks (Gosling et al., 2004), but we showed in GIVE-1 that the results obtained for the GIVE Challenge are comparable and more informative than those obtained from a laboratory-



World 1 World 2 World 3

Figure 2: The three GIVE-2 evaluation worlds.

based experiment (Koller et al., 2009b).

We also tried to leverage social networks for recruiting participants by implementing and advertising a Facebook application. Because of a software bug, only about 50 participants could be recruited in this way. Thus tapping the true potential of social networks for recruiting participants remains a task for the next installment of GIVE.

3.3 Evaluation worlds

Fig. 2 shows the three virtual worlds we used in the GIVE-2 evaluation. Overall, the worlds were more difficult than the worlds used in GIVE-1, where some NLG-systems had success rates around 80% in some of the worlds. As for GIVE-1, the three worlds were designed to pose different challenges to the NLG systems. World 1 was intended to be more similar to the development world and last year's worlds. It did have rooms with more than one button of the same color, however, these buttons were not located close together. World 2 contained several situations which required more sophisticated referring expressions, such as rooms with several buttons of the same color (some of them close together) and a grid of buttons. Finally, World 3 was designed to exercise the systems' navigation instructions: one room contained a "maze" of alarm tiles, and another room two long rows of buttons hidden in "booths" so that they were not all visible at the same time.

3.4 Timeline

After the GIVE-2 Challenge was publicized in June 2009, fifteen researchers and research teams declared their interest in participating. We distributed a first version of the software to these teams in August 2009. In the end, six teams submitted NLG systems (two more than in GIVE-1); one team submitted two independent NLG systems, bringing the total number of NLG systems up to seven (two more than in GIVE-1). These were connected to a central matchmaker that ran for a bit under three months, from 23 February to 17 May 2010.

3.5 NLG systems

Seven NLG systems were evaluated in GIVE-2:

- one system from the Dublin Institute of Technology ("D" in the discussion below);
- one system from Trinity College Dublin ("T");
- one system from the Universidad Complutense de Madrid ("M");
- one system from the University of Heidelberg ("H");
- one system from Saarland University ("S");
- and two systems from INRIA Grand-Est in Nancy ("NA" and "NM").

Detailed descriptions of these systems as well as each team's own analysis of the evaluation results can be found at `http://www.give-challenge.org/research`.

4 Results

We now report the results of GIVE-2. We start with some basic demographics; then we discuss objective and subjective evaluation measures. The data for the objective measures are extracted from

the logs of the interactions; whereas the data for the subjective measures are obtained from a questionnaire which asked subjects to rate various aspects of the NLG system they interacted with.

Notice that some of our evaluation measures are in tension with each other: For instance, a system which gives very low-level instructions may allow the user to complete the task more quickly (there is less chance of user errors), but it will require more instructions than a system that aggregates these. This is intentional, and emphasizes our desire to make GIVE a friendly comparative challenge rather than a competition with a clear winner.

4.1 Demographics

Over the course of three months, we collected 1825 valid games. This is an increase of almost 60% over the number of valid games we collected in GIVE-1. A game counted as valid if the game client did not crash, the game was not marked as a test game by the developers, and the player completed the tutorial.

Of these games, 79.0% were played by males and 9.6% by females; a further 11.4% did not specify their gender. These numbers are comparable to GIVE-1. About 42% of users connected from an IP address in Germany; 12% from the US, 8% from France, 6% from Great Britain, and the rest from 35 further countries. About 91% of the participants who answered the question self-rated their English language proficiency as "good" or better. About 65% of users connected from various versions of Windows, the rest were split about evenly between Linux and MacOS.

4.2 Objective measures

The objective measures are summarize in Fig. 3. In addition to calculating the percentage of games users completed successfully when being guided by the different systems, we measured the time until task completion, the distance traveled until task completion, and the number of actions (such as pushing a button to open a door) executed. Furthermore, we counted how many instructions users received from each system, and how many words these instructions contained on average. All objective measures were collected completely unobtrusively, without requiring any action on the user's part. To ensure comparability, we only counted successfully completed games.

task success: Did the player get the trophy?

duration: Time in seconds from the end of the tutorial until the retrieval of the trophy.

distance: Distance traveled (measured in distance units of the virtual environment).

actions: Number of object manipulation actions.

instructions: Number of instructions produced by the NLG system.

words per instruction: Average number of words the NLG system used per instruction.

Figure 3: Objective measures.

Fig. 4 shows the results of these objective measures. Task success is reported as the percentage of successfully completed games. The other measures are reported as the mean number of seconds/distance units/actions/instructions/words per instruction, respectively. The figure also assigns systems to groups A, B, etc. for each evaluation measure. For example, users interacting with systems in group A had a higher task success rate, needed less time, etc. than users interacting with systems in group B. If two systems do *not* share the same letter, the difference between these two systems is significant with $p < 0.05$. Significance was tested using a χ^2-test for task success and ANOVAs for the other objective measures. These were followed by post-hoc tests (pairwise χ^2 and Tukey) to compare the NLG systems pairwise.

In terms of task success, the systems fall pretty neatly into four groups. Note that systems D and T had very low task success rates. That means that, for these systems, the results for the other objective measures may not be reliable because they are based on just a handful of games. Another aspect in which systems clearly differed is how many words they used per instruction. Interestingly, the three systems with the best task success rates also produced the most succinct instructions. The distinctions between systems in terms of the other measures is less clear.

4.3 Subjective measures

The subjective measures were obtained from responses to a questionnaire that was presented to users after each game. The questionnaire asked users to rate different statements about the NLG

	D	H	M	NA	NM	S	T
task success	9% C D	11% C	13% C	47% A	30% B	40% A	3% D
duration	888 C	470 A B	407 A B	344 A	435 A B	467 B	266 A B
distance	231 B	164 A B	126 A	162 A B	167 A B	150 A	89 A B
actions	25 A	22 A	17 A	17 A	18 A	17 A	14 A
instructions	349 A B	209 A	463 B	224 A	244 A	244 A	78 A
words per instruction	15 D	11 C	16 E	6 A	10 B	6 A	18 E

Figure 4: Results for the *objective* measures.

	D	H	M	NA	NM	S	T
overall quality question	-33 C	-18 C	-12 C	36 A	18 B	19 B	-25 C
quality measures (summed)	-183 B	-148 B	-18 B	373 A	239 A	206 A	-44 B
emotional affect measures (summed)	-130 B C	-103 C	-90 B C	20 A	-5 A C	0 A B C	-88 A C

Figure 5: Results for item assessing overall instruction quality and the aggregated quality and emotional affect measures.

system using a continuous slider. The slider position was translated to a number between -100 and 100. Figs. 7 and 6 show the statements that users were asked to rate as well as the results. These results are based on all games, independent of the success. We report the mean rating for each item, and, as before, systems that do not share a letter, were found to be significantly different ($p < 0.05$). We used ANOVAs and post-hoc Tukey tests to test for significance. Note that some items make a positive statement about the NLG system (e.g., Q1) and some make a negative statement (e.g., Q2). For negative statements, we report the reversed scores, so that in Figs. 7 and 6 greater numbers are always better, and systems in group A are always better than systems in group B.

In addition to the items Q1–Q22, the questionnaire contained a statement about the overall instruction quality: "Overall, the system gave me good directions." Furthermore notice that the other items fall into two categories: items that assess the quality of the instructions (Q1–Q15) and items that assess the emotional affect of the interaction (Q16–Q22). The ratings in these categories can be aggregated into just two ratings by summing over them. Fig. 5 shows the results for the overall question and the aggregated ratings for quality measures and emotional affect measures. The three systems with the highest task success rate get rated highest for overall instruction quality. The aggregated quality measure also singles out the same group of three systems.

4.4 Further analysis

In addition to the differences between NLG systems, some other factors also influence the outcomes of our objective and subjective measures. As in GIVE-1, we find that there is a significant difference in task success rate for different evaluation worlds and between users with different levels of English proficiency. Fig. 8 illustrates the effect of the different evaluation worlds on the task success rate for different systems, and Fig. 9 shows the effect that a player's English skills have on the task success rate. As in GIVE-1, some systems seem to be more robust than others with respect to changes in these factors.

None of the other factors we looked at (gender, age, and computer expertise) have a significant effect on the task success rate. With a few exceptions the other objective measures were not influenced by these demographic factors either. However, we do find a significant effect of age on the time and number of actions a player needs to retrieve the trophy: younger players are faster and need fewer actions. And we find that women travel a significantly shorter distance than men on their way to the trophy. Interestingly, we do not find

D	H	M	NA	NM	S	T
Q1: The system used words and phrases that were easy to understand.						
45	26	41	62	54	58	46
			A	A	A	A
B		B		B		B
C	C	C				
Q2: I had to re-read instructions to understand what I needed to do.						
-26	-9	3	40	8	19	0
			A			
		B		B	B	B
	C	C				C
D	D					
Q3: The system gave me useful feedback about my progress.						
-17	-30	-31	9	11	-13	-27
			A	A		
B		B			B	B
C	C	C				C
Q4: I was confused about what to do next.						
-35	-27	-18	29	9	5	-31
			A			
				B	B	
C	C	C				C
Q5: I was confused about which direction to go in.						
-32	-20	-16	21	8	3	-25
			A	A		
				B	B	
C	C	C				C
Q6: I had no difficulty with identifying the objects the system described for me.						
-21	-11	-5	18	13	20	-21
			A	A	A	
		B		B		
C	C	C				C
Q7: The system gave me a lot of unnecessary information.						
-22	-9	6	15	10	10	-6
		A	A	A	A	
		B		B	B	B
	C	C				C
D	D					D

D	H	M	NA	NM	S	T
Q8: The system gave me too much information all at once.						
-28	-8	9	31	8	21	15
			A		A	A
		B		B	B	B
C	C					
Q9: The system immediately offered help when I was in trouble.						
-15	-13	-13	32	3	-5	-23
			A			
B	B	B		B	B	
C	C				C	C
Q10: The system sent instructions too late.						
15	15	9	38	39	14	8
			A	A		
B	B	B			B	B
Q11: The system's instructions were delivered too early.						
15	5	21	39	12	30	28
			A		A	A
B		B			B	B
C		C		C		C
D	D	D		D		
Q12: The system's instructions were visible long enough for me to read them.						
-67	-21	-19	6	-14	0	-18
			A		A	
				B	B	B
	C	C		C		C
D						
Q13: The system's instructions were clearly worded.						
-20	-9	1	32	23	26	6
			A	A	A	
				B	B	B
	C	C				C
D	D					
Q14: The system's instructions sounded robotic.						
16	-6	8	-4	-1	5	1
A		A	A	A	A	A
	B	B	B	B	B	B
Q15: The system's instructions were repetitive.						
-28	-26	-11	-31	-28	-26	-23
A	A	A			A	A
B	B		B	B	B	B

Figure 7: Results for the *subjective* measures assessing the *quality* of the instructions.

D	H	M	NA	NM	S	T
Q16: I really wanted to find that trophy.						
-10	-13	-9	-11	-8	-7	-12
A	A	A	A	A	A	A
Q17: I lost track of time while solving the overall task.						
-13	-18	-21	-16	-18	-11	-20
A	A	A	A	A	A	A
Q18: I enjoyed solving the overall task.						
-21	-23	-20	-8	-4	-5	-21
A		A	A	A	A	A
B	B	B	B			B
Q19: Interacting with the system was really annoying.						
-14	-20	-12	8	-2	-2	-14
			A	A	A	
B		B		B	B	B
C	C	C				C
Q20: I would recommend this game to a friend.						
-36	-39	-31	-30	-25	-24	-31
A	A	A	A	A	A	A
Q21: The system was very friendly.						
0	-1	5	30	20	19	5
			A	A	A	
		B		B	B	B
C		C			C	C
D	D	D				D
Q22: I felt I could trust the system's instructions.						
-21	-6	-3	37	23	21	-13
			A	A	A	
B	B	B				B

Figure 6: Results for the *subjective* measures assessing the *emotional affect* of the instructions.

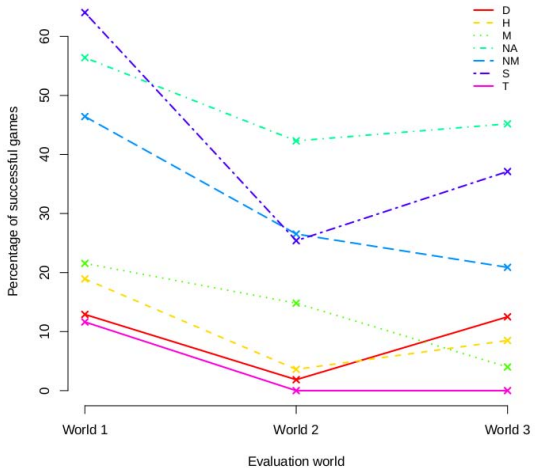


Figure 8: Effect of the evaluation worlds on the success rate of the NLG systems.

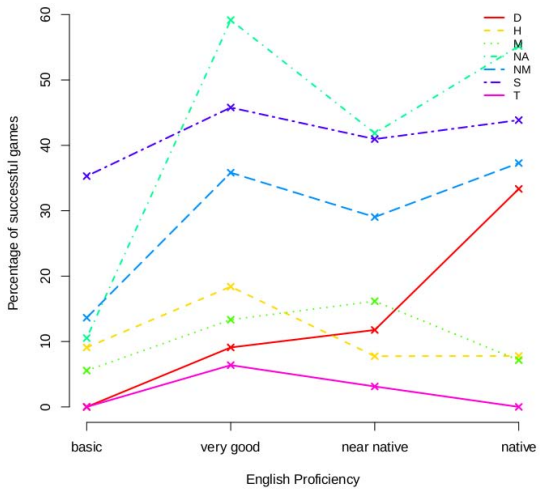


Figure 9: Effect of the players' English skills on the success rate of the NLG systems.

a significant effect of gender on the time players need to retrieve the trophy as in GIVE-1 (although the mean duration is somewhat higher for female than for male players; 481 vs. 438 seconds).

5 Conclusion

In this paper, we have described the setup and results of the Second GIVE Challenge. Altogether, we collected 1825 valid games for seven NLG systems over a period of three months. Given that this is a 50% increase over GIVE-1, we feel that this further justifies our basic experimental methodology. As we are writing this, we are preparing detailed results and analyses for each participating team, which we hope will help them understand and improve the performance of their systems.

The success rate is substantially worse in GIVE-2 than in GIVE-1. This is probably due to the

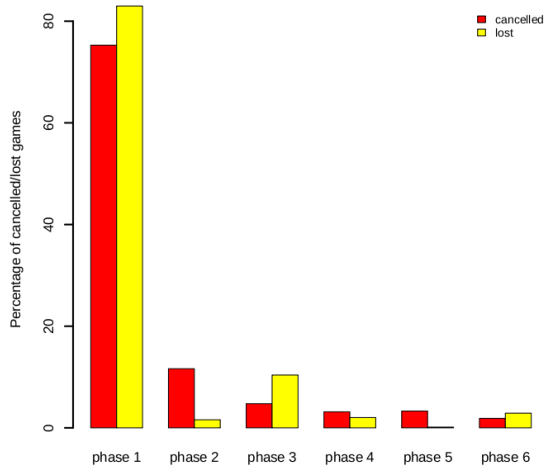


Figure 10: Points at which players lose/cancel.

harder task (free movement) explained in Section 2 and to the more complex evaluation worlds (see Section 3.3). It was our intention to make GIVE-2 more difficult, although we did not anticipate such a dramatic drop in performance. GIVE-2.5 next year will use the same task as GIVE-2 and we hope to see an increase in task success as the participating research teams learn from this year's results.

It is also noticeable that players gave mostly negative ratings in response to statements about immersion and engagement (Q16-Q20). We discussed last year how to make the task more engaging on the one hand and how to manage expectations on the other hand, but none of the suggested solutions ended up being implemented. It seems that we need to revisit this issue.

Another indication that the task may not be able to capture participants is that the vast majority of cancelled and lost games end in the very beginning. To analyze at what point players lose or give up, we divide the game into phases demarcated by manipulations of buttons that belong to the 6-button safe sequence. Fig. 10 illustrates in which phase of the game players lose or cancel.

We are currently preparing the GIVE-2.5 Challenge, which will take place in 2010-11. GIVE-2.5 will be very similar to GIVE-2, so that GIVE-2 systems will be able to participate with only minor changes. In order to support the development of GIVE-2.5 systems, we have collected a multilingual corpus of written English and German instructions in the GIVE-2 environment (Gargett et al., 2010). We expect that GIVE-3 will then extend the GIVE task substantially, perhaps in the direction of full dialogue or of multimodal interaction.

Acknowledgments. GIVE-2 was only possible through the support and hard work of a number of colleagues, especially Konstantina Garoufi (who handled the website and other publicity-related issues), Ielka van der Sluis (who contributed to the design of the GIVE-2 questionnaire), and several student assistants who programmed parts of the GIVE-2 system. We thank the press offices of Saarland University, the University of Edinburgh, and Macquarie University for their helpful press releases. We also thank the organizers of Generation Challenges 2010 and INLG 2010 for their support and the opportunity to present our results, and the seven participating research teams for their contributions.

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