Issues in corpus development for multi-party multi-modal task-oriented dialogue

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Abstract
This paper describes the development of a multi-modal corpus based on multi-party multi-task driven common goal oriented spoken language interaction. The data consists of approximately 10 hours of audio human simulation radio data and nearly 5 hours of video and audio face-to-face sessions between human trainees and virtual agents.

1. Introduction
Corpus-based approaches to dialogue have become an increasingly important part of dialogue agent design, providing a scope of the real issues that need to be dealt with in order to engage in natural dialogue with humans, as well as providing the basic data for statistical methods for language processing. While there has been much work on dyadic conversation, both casual (e.g., Switchboard [Jurafsky et al., 1998]) and task oriented (e.g., Maptask [Carletta et al., 1996] and Trains [Heemann and Allen, 1994]), there has been much less emphasis on multi-party dialogue. The mission rehearsal exercise project (MRE) (Swartout et al., 1996) and Trains (Heemann and Allen, 1994), there has been much less emphasis on multi-party dialogue. The mission rehearsal exercise project (MRE) (Swartout et al., 2004) has the ambitious aim of virtual reality training of a decision-maker in a multi-party mission-related setting. This activity differs from those found in existing available corpora in several aspects:

- there are multiple participants communicating in a variety of modalities (face to face, over the radio)
- talk is centered around a central “mission” and actions taken to further that mission and cope with issues that arise while carrying out that mission. Talk is not a single short dialogue, but a series of “dialogue episodes”, each of which may be between different participants, using different modalities, and separated by periods of non-talk, while acting in the environment or waiting for results of previous interaction.
- The participants involved have a rich social structure, including hierarchical status and differing areas of competence and responsibility.
- There are domain and genre-specific aspects of interaction, including special terms and phrases.

These differences not only necessitate developing corpora as a resource for analysis in such domains, they require some special features in corpus design and annotation. This paper describes our current status in developing such a corpus. In the next section we describe the domain of the MRE system and describe features of the data types comprising our corpus. In section 3, we describe preliminary observations on the corpus, and in section 4, we discuss future work.

2. MREC Domain Description
The specific activities we are concerned with are military mission-related training activities. The MRE virtual reality training project is set within the specific domain of decision-making for a platoon-leader in a peace-keeping mission in Bosnia. The system is set in a room with 150 degree field of view screen with 3-D immersive sound. The trainee plays the role of a lieutenant who is given the mission to assist another platoon in a weapons inspection. En-route, he encounters an accident between an army vehicle and civilian car, with an injured boy lying wounded on the ground. He must decide whether to help the boy, continue on his assigned mission, or split his forces and attempt both actions. He may interact with a number of visually accessible characters (the sergeant, a medic, the boy’s mother), as well as characters over the radio, such as the base and the increasingly desperate commander of the other platoon.

2.1. MRE Bosnia
In order to get a good sense of how a trainee might react within a near-term realistic situation, it was important to constrain the range of responses to something approximating the anticipated experience. While initially this data was gathered with a wizard of oz interface, we have increasingly relied on data from actual runs of the MRE system itself to further develop both task inclusion and improvement of the dialogue system. The average length of these dialogues is 618 total words, broken into 128 utterances, on average (49 human utterances and 79 agent utterances). Table 1 shows the average amounts of MRE dialogue per recording session (each consisting of several dialogues with different participants). Although the human lieutenant talks more than any one character, it is slightly unusual that the agents together talk more than the Lieutenant. One can also notice a trend for the humans to talk less and the agents to speak for a higher percentage of the total interaction.

The multi-participant, multimodal nature of the MRE scenario can yield complex overlapping dialogues, as in fig-
The first activity (MZ) consists of short disjoint radio communication episodes from training exercises at Fort Leonard Wood. A much larger data set (SIM) consists of a single hour and twenty minute simulation exercise from Fort Rucker, involving trainees using flight simulators, exercising a coordinated mission with a command post and semi-automated simulated forces. This exercise contains communication on multiple radio channels involving often simultaneous speech, yielding nearly 10 hours total of speech, when separating out each channel. The recordings include both actual radio communication between physically separate people and communication between team members in the same location, captured over an open channel. A short fragment of the interaction is shown in Figure 2.

As can be seen in this fragment, not all sides of a dialogue occur on the same channel. The two members of the rogue 07 helicopter can be heard on channel 8. Channel 8 also captures their communication with other units, but this is also captured on other frequencies (45 for Savoy 06, and 42 for Rogue 06). The communication from Rogue 06 only appears on channel 42, so some of the content on channel 8 has only one side of a dialogue episode (which other bits are repeated on multiple frequencies). This situation presented a number of problems, including the need to correlate the data between eight channels, both to avoid redundancy of data, as well as to form a coherent picture of the multiple dialogues occurring at the same time. To track the dialogues, we code the addressee as well as mode (radio or normal), as in the MRE data. In the SIM data, there are also more complex issues of role and identity. Rogue Zero Seven (R07 in the example) is a team entity made up of two individual speakers, who speak to each other off radio but are generally indistinguishable to other radio callers (e.g. either may answer a call addressed to R07 or send a call as R07). Thus the corpus can be searched by individual speakers’ dialogue, specific roles, or extended teams.

Though the addressee and mode coding allows most dialogues to be distinguished, the high number of speakers on some channels creates overlaps and affects dialogues that are otherwise distinct. For example in Figure 3, two people are calling ops at the same time for the same speaker, but are not in the same dialogue (and cannot hear each other when they are both speaking).

Table 1: Average dialogue size by collection period

| Date | Human | Agent | Combined |
|------|-------|-------|----------|
| Mar  | 410   | 350   | 760      |
| May  | 260   | 449   | 709      |
| Aug  | 198   | 314   | 512      |
| Nov 6| 153   | 358   | 511      |
| Nov 20| 257 | 525 | 782      |
| Dec  | 192   | 349   | 541      |

Table 2: Radio Data

| Name | Speakers | Utterances | Words |
|------|----------|------------|-------|
| MZ   | 17       | 151        | 1912  |
| SIM  | 38       | 2677       | 29227 |
| Total| 55       | 2828       | 31139 |

Figure 1: Example of MRE interaction

By collecting dialogues of a human trainee interacting with the virtual characters we can both evaluate and improve aspects of the system, such as speech recognition, natural language understanding, and dialogue interaction. For system evaluation, the MRE corpus is currently being coded for several phenomena at both utterance and subdialogue levels, tracking the lieutenant’s attempted tasks, and response quality of the agents. (see Traum et al., 2004) for more details). We also plan to study how human users react to virtual agents. We approach the analysis both quantitatively and qualitatively by using the coding schemes mentioned in section 4.

2.2. Military Radio

In order to investigate features of dialogue in this domain, we are building a corpus of human-human radio communication from military training exercises. The current state of the corpus is shown in Table 2.

| Speaker | Addr | Mode | Text |
|---------|------|------|------|
| Sgt     | Lt   | normal | sir we should have first squad reinforce the lz |
| Medevac | Lt   | radio  | eagle two six this is medevac two one |
| Medevac | Lt   | radio  | turning final now |
| Medevac | Lt   | radio  | have lz in sight |
| Lt      | Sgt  | normal | roger. have first squad reinforce the lz |

Figure 3: Example of SIM multiple dialogues

Thus dialogue episodes are tracked and episode information is coded on an utterance level. Episodes are also categorized by activity type classified according to the following 7 supercategories, which are based on the dialogue’s general orientation to the task actions. Subcategories describe variations in dialogue formality, topic orientation and/or speaker and addressee’s orientation to the information (e.g. whether speaking of one’s own action status or observed data). While some categories are specific to this
domain (e.g. 'Radio Check'), most of the domain-specific information occurs in subcategories, while the supercategories are transferable across domains.

1. Radio Check
2. Task Allocation: Orders, Action Prompt, Negotiating Task
3. Status Report: Call, Action Status, Narrating
4. Information Sharing: Spot Report, FYI, Advising
5. Information Gathering: Request Action Status, Data Request, Procedural Clarification Request
6. Achieving Task: Action Clearance, Coordinating Action, Problem Solving
7. Socializing: Storytelling, Commenting

3. Preliminary Results

Table 3 shows the amount of transcribed data at this stage of the development of the corpus, as well as the size of the total vocabulary for MRE agents vs. humans and SIM data.

| Type     | Speakers | Utterances | Words | Unique |
|----------|----------|------------|-------|--------|
| MRE Agents | 8        | 2,373      | 11,766 | 222     |
| MRE Human  | 22       | 1,480      | 6,833  | 466     |
| SIM       | 38       | 2,677      | 29,227 | 1,567   |

Table 3: MRE and SIM by utterances, words, and unique words

In MRE, the Agents spoke 11,766 words, although their total used vocabulary size was only 222 distinct words. Though we have had 30 tests, the human vocabulary is only twice as big, reflecting the narrow focus of the scenario. Although we may expect some vocabulary increase with subsequent tests, increase in vocabulary has declined to almost zero in our most recent test runs, as shown in figure 4.

The human data in the MRE vs Radio corpus displays both similarities and differences due to the features of the domains and modalities. Utterances in the MRE tests tend to be much shorter, with an average length of 4.6 words per utterance as opposed to 11 in the radio data. This coincides with the different intonation data in table 4.

The breakdown of intonation types show that falling and continuing intonation is predominant overall, which means that we may expect many questions being uttered with nonrising intonation. In the MRE data the falling intonation dominates much more than in the radio data, in part due to the shorter utterance lengths, also possibly a higher number of command statements. A co-occurrence study with the types and amount of core acts (see section 4) will help us build more theories on the character of the data.

The lexical patterns of each corpus are suggestive of broader trends in the data as well. In the MRE domain, which is a relatively brief and enclosed scenario, words for entities (sergeant, lz, squad, tucci, boy) and actions (secure, send) are in the top ten rank frequency. In the longer, more complex SIM domain, elements of call signs (zero, six, two, rogue, roger) are among the most frequent items, as they play an important role in radio communication (Martinovski et al., 2003).

Table 5 compares the frequency of the top ten and selected words in spoken English (from British National Corpus: http://www.comp.lancs.ac.uk/ucrel/bncfreq/flists.html) with the SIM training simulation data and the human utterances from MRE.

There are several striking patterns of frequency differences in common words that seem to support some of our intuitive characterization of the domains.

Team oriented data: Though 'we' is slightly more common in our data, 'I' is significantly less common in both corpora, 10 times less frequent in MRE than BNC.
Currently we have coded a portion of SIM and will expand to MRE utterance unit level coding for more productive co-occurrence studies. These coding categories include grammatical coding (sentence structure and ellipsis), reference coding, a wide range of dialogue acts (e.g. suggestion, request, statement, answer, politeness), grounding acts (Traum and Allen, 1994), and communication management (interactive reformulation, hesitation sound) (Martinovski, 2001).

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| Word | BNC # | BNC freq | SIM # | SIM freq | MRE # | MRE freq |
|------|-------|----------|-------|----------|-------|----------|
| the  | 1     | 3.961    | 5     | 2.922    | 1     | 10.22    |
| is   | 3     | 2.784    | 23    | 1.187    | 70    | 0.278    |
| you  | 4     | 2.596    | 11    | 1.108    | 1     | 21.04    |
| and  | 5     | 2.521    | 17    | 1.512    | 30    | 0.746    |
| it   | 6     | 2.451    | 31    | 0.674    | 77    | 0.263    |
| to   | 7     | 2.186    | 6     | 2.522    | 5     | 3.322    |
| that | 8     | 2.150    | 20    | 1.351    | 26    | 0.834    |
| a    | 9     | 1.864    | 22    | 1.204    | 17    | 1.215    |

Table 5: Rank and frequency per 100 words in British National Corpus Spoken Data, SIM and MRE human data.

Task/Simulation Immersion: ‘is’ roughly equal to BNC, but past lexeme ‘was’ is several times less frequent in SIM and nearly 10 times less frequent in MRE. An indicator of future planning ‘will’ (also includes ‘ll’) is also strongly less frequent in MRE, perhaps due to the limited time frame and immersion in events directly surrounding the Lt. SIM, which has much more complex interactions between teams coordinating to fulfill their missions has a comparable level.

Pronouns in general (excepting ‘we’) are less frequent in our data, particularly 3rd person reference, perhaps again due to the immersion in the present task at hand, but also likely due, especially in the MRE dialogue, to short statements. The lower frequency of ‘and’ in the MRE data and the much higher occurrences (over 10%) of ‘the’ support this observation as well. The MRE utterances also appear more controlled and carefully spoken, given the extremely low occurrence of hesitation sounds. Finally, ‘what’ and ‘where’ occur with much higher frequency in MRE than in the other data. It is unclear at this point whether this is a result of the specific scenario (where the lieutenant meets his platoon mid action) or possibly a more general feature of simulated experience, where the human participant relies on the agents for information to help him immerse more fully in their world.

4. Future Plans

The result of the domain specific annotations described above is a corpus that may be searched by utterance, interaction unit, speaker or entity, or by subdialogue activity.

\(^1\)Includes “erm”, “uh” and “um”.

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