iNAGO Project Report: Template-based Intent Classifier

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This report will introduce the template-based dialogue intent classifier. The report will discuss the templates used in detail, and evaluate the classifier using metrics inspired by information theory.

1 Overview of the Data and the Classifier

By the time this report is written, there are $1,033$ data in total as our training data. and among those data, $212\frac{1}{6}$ of them are tagged **"operational"**, $298\frac{1}{6}$ of them are tagged **"situational"**, $403\frac{2}{3}$ of them are tagged **"definitional"**. There are fractions because we allowed multiple classes to exist simultaneously on the same dialogue, in those cases a label will worth less. (e.g. if a dialogue is both definitional and situational, it is counted to be $\frac{1}{2}$ definitional and $\frac{1}{2}$ situational)

It is also worth noticing the fact that there are 119 out of $1,033$ dialogues tagged as **"others"**, meaning there are uncertainties in their taggings, or they do not belong to any of the three classes. They are excluded from the first three classes. i.e. if a dialogue is labelled as **"others"**, they are not labelled as any of the three classes at the same time.

After some work around the first stage data, several templates are summarized and tested. The templates are used to classify whether a dialogue belongs to the **definitional** class or not. The report will describe those templates in the next section in detail.

2 Intent Classifier: Templates

The template-fitting algorithm uses **Trie** data structure, hence it is difficult to track the exact number of cases falling into each template. However, the below describes all the templates used in detail.

Note: in the following descriptions, "∗" denotes arbitrary words or phrases. e.g. what is ∗ can represent both "what is ACC" and "what is that thing over there".

In addition, "x/y" will denote that x and y are on the same level. e.g. what is/are ∗ means what is ∗ OR what are ∗.

2.1 Template Set 1: Templates with High Confidence and Priority

Due to the nature of Trie and our classification, system, we want to insert some templates prior to others in order to establish priority. For example, "what is that ∗" is at a higher priority than "what is ∗". Although by definition, "what is ∗" will include "what is that ∗", however, they will be classified as definitional and situational respectively. Hence, it is important to insert some templates before others, which will exclude them from more general or larger templates.

In this section, the templates listed has the highest priority, as they are highly likely to guarantee certain classifications with no errors (at least from the training data). They will be the first set of templates inserted to the Trie.

They are:

- tell me ∗, can you tell me ∗, about ∗, mia ∗, turn on ∗

Note: The above are very common prompt phrases user will give to indicate a **definitional** dialogue.

- can i ∗ this/that/{on the}/{in the}/{with the}/my ∗
- what/how do/should i ∗ if/when ∗

Note: A very promising set of templates that indicates **situational** dialogues.

- what/how do/should i/you/one ∗

Note: Though it is very similar to the above cases, this more general set of template is a clear indication of **operational** dialogues.

As listed, those are the 4 pieces of templates that works very well for each corresponding classes.

2.2 Template Set 2: Situational Templates Pack

As one of the example shown above, it is observed that most situational dialogues will fit into some definitional templates as they tend to be more general. To avoid such cases, we insert some situational templates prior to those more general templates.

This set includes the following templates:

- what/where is/are this/that/these/those/my ∗
- what/where is/are ∗ {on/in/with my/the} ∗
- what ∗ do/does ∗ **verb** if/when ∗
- what ∗ do/does this/that ∗ **verb**
- what do/does this/that/the ∗ mean
- do/does this/that/my ∗ have ∗
- do i have/need ∗

- how do/does ∗ **verb** if/when ∗
- how do/does this/that ∗ work
- why is/isn't/are/ain't my ∗
- is/are ∗ open ∗

As listed, those are the 11 pieces of templates that works very well for classifying **situational** dialogues.

2.3   Template Set 3: The Rest of Definitional Templates

After establishing the priority of situational templates (operational templates are all included in the first set), it leaves us the rest of the templates prepared. All of them corresponds to **definitional** dialogues.

They are:

- how many/much ∗
- how often ∗
- what ∗ is/are there ∗
- what make/makes ∗
- do/does ∗ turn on/off ∗
- when do/does/should/would ∗
- what/which/where/when can/may/could/might i ∗
- what can/should i do with ∗
- what will happen if ∗
- what/where is/are ∗
- what do/does ∗ do
- what ∗ do/does ∗ **verb**
- how do/does ∗ work/help
- can i ∗

Those are all the templates prepared in this model. A dialogue that does not fit into any of those templates will not be given a classification at all. Such case does not appear that frequently, we will discuss this in the later part of the report.

2.4   Another Specific Form: bare nouns

In addition to templates, we also look for **bare nouns** in dialogues. If an entry is a bare noun, it is almost certain that the dialogue will belong to **definitional** dialogues.

3   Some data regarding the classifier

Through the 914 dialogues we have, the classifier was able to label 850 dialogues, leaving 64 dialogues classified.

Among the 850 dialogues, it has an accuracy of 94% (it classifies 800 dialogues with the correct label).

Among the $392\frac{5}{6}$ dialogues classified as **defnitional**, $372\frac{1}{2}$ of them are labeled correctly.

Among the $232\frac{1}{3}$ dialogues classified as **situational**, $225\frac{2}{3}$ of them are labeled correctly.

Among the $224\frac{5}{6}$ dialogues classified as **operational**, $201\frac{5}{6}$ of them are labeled correctly.

And for the 64 dialogues that were unclassified, 30.5 of them are **defnitional**, 29 of them are **situational**, 4.5 of them are **operational**.

These data is calculated from a program provided in the attachment. They will be very useful in the evaluation part below.

4 Classifier Evaluation

To evaluate the classifier, the metric of information gain is used. The information gain and informational entropy is a concept in information theory that describes how much we know from a given set of data. In our case, our dataset has three potential classes, therefore the maximum entropy in a dataset will be a completely even split, hence $\log_2 3$.

For a random variable X, the informational entropy of it is defined as:

$$H(X) = -\sum_x P(x)\log_2 P(x)$$

In our case, our target random variable is "What class does a dialogue belongs to". Besides the 119 unclassified dialogues, we have $403\frac{2}{3}$ definitional dialogues, $298\frac{1}{6}$ situational dialogues and $212\frac{1}{6}$ operational dialogues. Therefore, its entropy without a classifier is:

$$H(\text{unclassified}) = -\frac{403\frac{2}{3}}{914}\log_2\frac{403\frac{2}{3}}{914} - \frac{298\frac{1}{6}}{914}\log_2\frac{298\frac{1}{6}}{914} - \frac{212\frac{1}{6}}{914}\log_2\frac{212\frac{1}{6}}{914} = 1.537$$

Which is very close to $\log_2 3 = 1.5849$ (which suggests it is very chaotic)

To calculate the average entropy after applying the templates, we have:

$$\tilde{H}(\text{classified}) = \frac{392\frac{5}{6}}{914} \cdot \left(-\frac{372\frac{1}{2}}{392\frac{5}{6}}\log_2\frac{372\frac{1}{2}}{392\frac{5}{6}} - \frac{392\frac{5}{6}-372\frac{1}{2}}{392\frac{5}{6}}\log_2\frac{392\frac{5}{6}-372\frac{1}{2}}{392\frac{5}{6}}\right)$$
$$+ \frac{232\frac{1}{3}}{914} \cdot \left(-\frac{225\frac{2}{3}}{232\frac{1}{3}}\log_2\frac{225\frac{2}{3}}{232\frac{1}{3}} - \frac{232\frac{1}{3}-225\frac{2}{3}}{232\frac{1}{3}}\log_2\frac{232\frac{1}{3}-225\frac{2}{3}}{232\frac{1}{3}}\right)$$
$$+ \frac{224\frac{5}{6}}{914} \cdot \left(-\frac{201\frac{5}{6}}{224\frac{5}{6}}\log_2\frac{201\frac{5}{6}}{224\frac{5}{6}} - \frac{224\frac{5}{6}-201\frac{5}{6}}{224\frac{5}{6}}\log_2\frac{224\frac{5}{6}-201\frac{5}{6}}{224\frac{5}{6}}\right)$$
$$+ \frac{30.5}{914} \cdot \left(-\frac{30.5}{64}\log_2\frac{30.5}{64} - \frac{29}{64}\log_2\frac{29}{64} - \frac{4.5}{64}\log_2\frac{4.5}{64}\right) = 0.382$$

The information gain is $H(\text{unclassified}) - \tilde{H}(\text{classified}) = 1.155$

From the above calculations, we can see that the classifier is information-wise efficient. This classifier is very useful in the future applications such as cutting down dialogue turns.

5 Conclusion

This report demonstrated the current dialogue classifier, and evaluated using metrics from information theory. With the classifier, we are able to progress further to tasks like cutting dialogue turns, giving more accurate answers, etc.