An Investigation of ISO-TimeML Applied to Vietnamese

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Abstract

This paper examines the application of the ISO-TimeML framework for semantic annotation of time and events in Vietnamese texts. A case study is presented to explore temporal entity annotation by analyzing various types of event and temporal information in Vietnamese. Additionally, all attributes represented within ISO-TimeML for event entities are analyzed, considering their applicability to the Vietnamese language. Our model's results are highly promising when compared to the performance of large language models and existing temporal extraction models for Vietnamese.

1 Introduction

One of the essential tasks in natural language processing is to comprehend temporal and event information associated with natural language expressions. Until now, there are only a few works on temporal and event expressions for Vietnamese as in (Lambert et al., 2012), (Tran et al., 2012) and especially in (Strötgen et al., 2014), where the authors proposed to build a small annotated corpus of Vietnamese article with temporal expressions as part of general named entities. However, there have been no published systematic study on the semantic annotation of events and temporal expressions for Vietnamese. In the framework of our project, we are interested in the annotation of temporal information in Vietnamese documents, using a standardized universal scheme for the sake of interoperability and consistency.

Several efforts had been made to develop TimeML (Pustejovsky et al., 2003), a specification language for representing and encoding events, temporal entities and relations in documents. This markup language is then integrated in the semantic annotation framework (SemAF-Time) of the ISO TC37/SC4 project for language resource management under the name of ISO-TimeML (Pustejovsky et al., 2010).

This paper introduces our work on the application of the annotation framework ISO-TimeML to the semantic annotation of Vietnamese texts. The paper is organized as follows. Section 2 presents a brief overview of ISO-TimeML.Section 3 explores events and temporal entities in Vietnamese in relation to the ISO-TimeML annotation scheme, examining various language-specific phenomena of Vietnamese. Section 4 presents our experiments in generating ISO-TimeML formatted event and temporal expressions for Vietnamese, by combining rules and dependency syntax. Conclusions and future works are found in Section 5.

2 ISO-TimeML

As mentioned above, ISO-TimeML is a XML-based markup language specified in the ISO SemAF-Time standard of semantic annotation framework for temporal information. This standard involves the annotation of all expressions having temporal import, including temporal expressions and eventualities. The specification of ISO-TimeML is composed of an abstract syntax of annotations, a concrete syntax in XML, and a semantics of ISO-TimeML. This paper focuses more on the abstract syntax of ISO-TimeML.

The ISO-TimeML standards include annotation schemes for entities corresponding to times and events on one hand, and relationships between these entities on the other hand. Stand-off annotation is employed in ISO-TimeML to mitigate the shortcomings of in-line labeling, especially when entities are discontinuous.

Assuming that all times and events are re-

ferred to as intervals, ISO-TimeML takes into account three aspects of the semantic description of an interval entity:

- Order: The position of the interval relative to others;

- Measure: The size of the interval;

- Quantity: The number of intervals.

Order and measure are annotated as entity links, while quantity involves the quantification annotation schema QuantML (Bunt et al., 2022).

2.1 Time Entities

In ISO-TimeML, temporal expressions are marked up with the <TIMEX3> tag with four main types: date, time, duration and set, as shown in Table 1 with examples in English.

Table 1: Time's types and examples in English.

Type	Explanation	Value Examples
date	Calendar time	John left between **Monday** and **Wednesday**
time	A time of the day, even in a very indefinite way	Mr. Smith left **ten minutes to three**
duration	Explicit durations	Mr. Smith stayed **2 months** in Boston
set	Set of times.	John swims **twice a week.**

Each time entity also has an binary attribute (temporalFunction) specifying if the time is not absolutely determined. For example, this attribute for *January 31* has a positive value, while it has a negative value for *Januray 31, 2024.*

2.2 Event Entities

Events are marked up with the <EVENT> tag with several attributes.

The class attribute contains 7 values: state, reporting, perception, aspectual, I-action, I-state, occurrence. A summary of these classes is shown in the Appendix (Table 5) (Saurí et al., 2006).

In addition to class attribute, event entities are also annotated with syntactic-semantic information, including part-of-speech, tense, aspect, verb form, modality, mood, and polarity.

2.3 Entity Links

Temporal expressions and events are linked together by four types of link tags (ISO, 2012): temporal links (TLINK - temporal relationship between events, times or between an event and a time), aspectual links (ALINK - relationship between an aspectual event and its argument event) and subordinating links (SLINK - relations between two events), measure links (MLINK - relation between events and duration).

2.4 ISO-TimeML Development and Implementation

The ISO semantic annotation schema are still far from complete. Recently many papers on the development and improvement of annotation schema have been published. For example, (Lee, 2015) about MLINK, (Zymla, 2018) on annotation scheme for tense/aspect, (Silvano et al., 2021) on designing multi-layer semantic annotation scheme based on ISO standards, (Yahiaoui and Atanassova, 2022) on temporal information in scientific papers.

Several temporal resources have been developed for English and other languages such as Italian (Caselli et al., 2011), French (Bittar et al., 2011), Chinese (Li et al., 2014), multilingual (Strötgen et al., 2014), etc..

For Vietnamese, the Association for Vietnamese Language and Speech Processing (VLSP) has developed and published various syntactically annotated corpora in the framework of VLSP 2020, 2021, 2022 and 2023 workshops [1]. Our ongoing project on the semantic annotation of Vietnamese document aims to develop a gold sembank for the VLSP community. To facilitate the compatibility of language resources, the annotation scheme will be developed in accordance with the established standards designed for this purpose.

The next section examines the application of the ISO-TimeML scheme to Vietnamese and discusses language-specific phenomena of Vietnamese related to event and temporal information.

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[1]https://vlsp.org.vn/conferences

3   Application of ISO-TimeML to Vietnamese

To analyze the applicability of the ISO-TimeML annotation framework to Vietnamese, this paper focuses on the exploration of time and event entities in Vietnamese. Subsection 3.1 introduces different temporal expressions in Vietnamese for each temporal type. Subsection 3.2 investigates various attributes of event entities in ISO-TimeML and their equivalent representation in Vietnamese.

3.1   Time Entities in Vietnamese

In Vietnamese, representing time may involve various word types and phrases. However, it mainly consists of nouns and nominal phrases.

The following sections show regular examples of Vietnamese time entities belonging to four main types of time entities specified in ISO-TimeML as listed in Table 1.

3.1.1   Date

Date entities consist of temporal expressions describing a calendar time. Here are some Vietnamese examples:

- Thứ Sáu (Friday)

- ngày 1-10-2023 (October 1, 2023)

- mùa hè năm nay (this year's summer)

- tuần trước (last week)

Amongst the examples above, the weekday may be ambiguous because thứ sáu also means "the sixth". So if one says ngày thứ sáu, both "Friday" and "the sixth day" make sense. This applies to all weekdays from Monday to Saturday (only Sunday is not equivalent to a order number).

3.1.2   Time

The examples below illustrate time entities referring to a time of the day.

- 9 giờ sáng ngày thứ Sáu (9 a.m Friday)

- buổi sáng hôm qua (yesterday's morning)

- tối qua (last evening).

We would like to bring attention to the annotation of some temporal expressions that demonstrates the benefit of using stand-off annotation. For example, given the phrase từ 2 đến 3 giờ (literally "from 2 to 3 o'clock"), two time entities need to be annotated: 2 giờ (o'clock) and 3 giờ (o'clock). However, 2 and giờ are not consecutive in the sentence. Stand-off annotation proves valuable in this case.

3.1.3   Duration

Below are some temporal phrases describing explicit duration.

- 2 tháng (2 months)

- 24 giờ (24 hours)

- cả đêm hôm qua (all last night)

3.1.4   Set

These last examples of time entities correspond to expressions describing a set of times.

- hai lần một tuần (twice a week)

- mỗi 2 ngày (every 2 days)

In summary, the annotation of time entities in Vietnamese doesn't differ much from other languages like English. The links between time entities for representing time ordering are similar.

3.2   Event Entities in Vietnamese

For event entities, ISO-TimeML offers various attributes, namely class, type, part-of-speech, tense, aspect, verb form, modality, mood, and polarity. Event class, as described in Table 5, type, modality, and polarity can be considered as universal. Therefore, this research will concentrate on the five remaining attributes and discuss the application of these specified attributes to Vietnamese event expressions.

3.2.1   Part-of-speech

As specified in ISO-TimeML, in Vietnamese, event entities also include verbs, nominalizations, adjectives, predicative clauses, or prepositional phrases.

From a comparative perspective, we would pay attention to the cases of phrasal verbs and nominalizations.

In Vietnamese, a predicate can be composed of a verb and another word of different parts-of-speech. In many cases, the composition involves a verb and a preposition or another verb indicating the orientation of the action. In those

cases, we can choose to mark only the head verb.

In many other cases, the predicate is composed of a verb corresponding to an action and another verb or an adjective determining the result of that action. For example, the English sentence "I hit the window" can be translated into the following sentence:

Tôi (I) đập (hit) cái kính (the glass),

while the translation of the sentence "I broke the window" is

Tôi (I) đập (hit) vỡ (broken) cái kính (the glass).

For these cases, the verb compound can be annotated as two separate events:

"Tôi (I) đập (hit) kính (glass)"

and

"kính (glass) vỡ (broke)".

As for nominalizations, recall that Vietnamese words are morphologically invariant. Instead, classifier nouns, such as cái, sự, việc, cuộc are added before verbal or adjectival predicate to form noun phrases. For example: sự (classifier meaning fact) cố gắng (try) meaning efforts, and cái (classifier for things) ăn (eat) meaning *foods*. Therefore, when annotating events expressed by means of nominalizations, it is necessary to focus on the main verb and record the classifier noun.

3.2.2 Tense, Aspect, Vform and Mood

These four attributes are typical for the specification of verbs in Indo-European languages. However, Vietnamese is a monosyllabic language which is morphologically invariant. This means that considering only the main predicate would not yield equivalent values for all the attributes mentioned above.

While the Vform attribute value is none for all events in Vietnamese, the tense, the aspect and the mood attribute can be specified in two ways: use of temporal adverbs or of temporal expressions.

For example, the adverb đang (i.e. in progress) can be used to express an event in present or present continuous tense. However, if we use a temporal expression like Bây giờ (i.e. now), the meaning of a sentence remains unchanged if the adverb đang is omitted in that sentence. The two sentences

1. Bây giờ (now), tôi (I) sống (live) ở (in) Hà Nội (Hanoi)

and

2. Bây giờ (now), tôi (I) đang (*in progress*) sống (live) ở (in) Hà Nội (Hanoi)

share similar meanings:

Now I am living in Hanoi.

The use of temporal expressions are illustrated in the following examples.

- For the past tense, commonly used words include trước (before), qua (past), such as: Hôm qua (yesterday), hôm trước (the day before), 3 hôm trước (3 days ago), 2 tuần trước (2 weeks ago).

  For example: Hôm qua (yesterday), tôi (I) đi (go) Hà Nội (Hanoi)" is understood in the past tense because of using hôm qua, instead of using adverb.

- For the present tense, typically used words include nay (today), này (now). For example: "Hôm nay (today), lúc này (at this moment).

- For the future tense, words like mai (tomorrow), sau (then) are commonly used. For example: ngày mai (tomorrow), hôm sau (the next day), tuần sau (next week).

Temporal expressions can be sometimes ambiguous, as shown in the following sentence:
Tôi (I) định làm (do) bài tập (homework) trong (in) 10 phút (minutes) nữa (later).

This sentence can be understood in two ways

1. *I'm doing homework and will finish in 10 minutes,*

2. *After 10 minutes, I will do my homework.*

It is interesting to note that the same temporal adverbial phrase trong 10 phút nữa (in the next 10 minutes) doesn't cause ambiguity in the following sentence:
Tôi (I) định đi (go) làm (work) trong (in) 10 phút (minutes) nữa (later)
with the only possible understanding:
From now until 10 minutes later, I will go to work,
without specifying the exact time.

The difference comes from the perception of the two main verbs: "to do" and "to go".

Finally, it is important to remember that in many cases, neither temporal adverbs nor temporal expressions can be found in a sentence.

In such instances, that single sentence is under-specified regarding tense or aspect attributes. These attribute values can be determined using information expressed in the discourse annotation.

4 Experiments

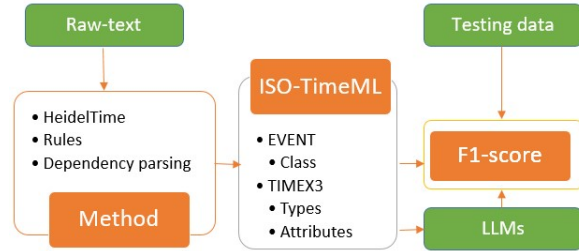To generate event and time expressions for Vietnamese, the workflow is described specifically in Figure 1.

Figure 1: Workflow for generating ISO-TimeML annotation for Vietnamese.

As mentioned earlier, our model will focus on extracting <EVENT></EVENT> and <TIMEX3></TIMEX3> tags for Vietnamese text.

To identify events, we concentrate on the main occurrences and utilize dependency parsing to extract the primary verbs and adjectives from the sentence. Then, the similarity of Vietnamese verbs to each class is evaluated based on the definitions provided for each class in English.

For temporal expressions, we selected HeidelTime[2] as the base model, and then refined and added necessary rules for Vietnamese. Next, our data will be processed using dependency parsing (Linh et al., 2020). All spans labeled *obl:tmod* (time-related label in dependency syntax) will be used to extract time expressions. At the same time, experiments will be conducted to craft prompts for several large language models, such as GPT-4[3] and Gemini[4], to generate ISO-TimeML for Vietnamese. Afterwards, the results of these models are described, followed by some discussions.

4.1 Dataset

The data used in our experiments is derived from the VLSP-NER 2021 dataset (Linh et al.,

2022). Since this dataset includes time tags for Vietnamese, all sentences containing these time tags are extracted. Then, our proposed process is applied to this extracted data. Additionally, we manually annotate 112 Vietnamese sentences, which are used as test data.

4.2 Metrics

The systems are evaluated using an adjusted scoring method. This involves calculating precision, recall, and F1 for each attribute by considering the number of event and temporal expressions with the correct attribute, the total number of event and temporal expressions in the gold standard, and the total number of event and temporal expressions in the system's output (Chang and Manning, 2012). The revised attribute scores based on the following formulas:

$$P_{att} = \#Correct_{att}/\#Mention_{resp}$$

$$R_{att} = \#Correct_{att}/\#Mention_{gold}$$

$$F_{1att} = 2 * P_{att} * R_{att}/(P_{att} + R_{att})$$

This formula will then be applied to each type of ISO-TimeML tag (<EVENT></EVENT>, <TIMEX3></TIMEX3>).

4.3 Results

For the <EVENT></EVENT> tag, we only focus on the "class" attribute. In contrast, the <TIMEX3></TIMEX3> tag includes multiple attributes: TYPE, Value, mod, temporalFunction, anchorTimeID, valueFromFunction, functionInDocument, beginPoint, endPoint, quant, and freq, as specified by the ISO-TimeML annotation guidelines.

For the <EVENT> tag, we assign values to the "class" attribute, which includes the following event classes: REPORTING, PERCEPTION, ASPECTUAL, I_ACTION, I_STATE, STATE, and OCCURRENCE. To identify events, we focus on main events and use dependency parsing to extract the primary verbs and adjectives from the sentence. The similarity of Vietnamese verbs to each class is then assessed based on the definitions provided for each class in English.

For the <TIMEX3> tag, we have developed additional rules for identifying time expressions in Vietnamese, modified HeidelTime's rules to

better suit Vietnamese, and integrated these with dependency parsing. Some of the time rule changes are listed in Table 2.

Table 2: Statistics on rule changes for identifying time expressions.

Model		DATE	TIME	DURATION	SET
HeidelTime		127	34	8	4
Our model	New rule	20	2	6	1
	Delete rule	2	0	0	0
	Modify rule	2	2	0	0
	New norm	2	0	8	1
	New pattern	15	5	0	1

The models experimented with include: Gemini, GPT-4 (using few-shot prompting for both), HeidelTime, and our improved model.

The results of the models for the <EVENT> tag are detailed in Table 3. Only three models are included here because HeidelTime does not handle event tags for Vietnamese. It can be seen that for event detection, Gemini is currently the most stable model with the best performance. Our model is still relatively modest, achieving 40.87%. GPT-4 has the lowest performance with 37.43%. These results could be due to various reasons, such as: the presence of multiple events in a sentence while the model identifies fewer (since we focus on main events), the difficulty of classifying event types for Vietnamese, etc.

Table 3: Results of all models for <EVENT> tag.

Model	P_{att}	R_{att}	F_{1att}
Gemini	54.22%	40.54%	46.39%
GPT_4o	41.30%	34.23%	37.43%
Our model	**39.50%**	**42.34%**	**40.87%**

Table 4 presents the results of our experiments with the four models for time tag. It shows that large language models (LLMs) underperformed, achieving only around 34.15% and 43.33%. HeidelTime came in third with 74.61%, a respectable score for a model that has been effective for Vietnamese over time. Our model, ranking first with 85.52%, demonstrates that the additional rules, enhancements, and integration with dependency parsing are well-suited and beneficial for Vietnamese.

We presents an example of the differences between the models with the sentence: "Sau khi chuẩn bị cẩn thận, chúng tôi đã báo cáo

Table 4: Results of all models for <TIMEX3> tag.

Model	P_{att}	R_{att}	F_{1att}
Gemini	48.24%	39.32%	43.33%
GPT_4o	38.02%	30.99%	34.15%
HeidelTime	83.07%	67.71%	74.61%
Our model	**89.01%**	**82.29%**	**85.52%**

hơn 1 tiếng." (*After careful preparation, we reported for over an hour.*")

For event annotation, all the models are tested with this sentence identified the two main events: "*prepare*" and "*report*":

<EVENT eid="e1" class="I_STATE"> chuẩn bị </EVENT>

<EVENT eid="e2" class="REPORTING"> báo cáo </EVENT>

For time annotation, most models can identify basic time expressions. However, our model provides additional annotations for time-specific phrases unique to Vietnamese:

- Gemini:

  <TIMEX3 tid="t1" type="DURATION" value="P1H">hơn 1 tiếng</TIMEX3>

- GPT-4:

  <TIMEX3 tid="t1" type="DURATION" value="P1H">hơn 1 tiếng</TIMEX3>

- HeidelTime:

  <TIMEX3 tid="t1" type="DURATION" value="P1H" mod="MORE_THAN"> hơn 1 tiếng </TIMEX3>

- Our model:

  <TIMEX3 tid="t3" type="DURATION" mod="AFTER"> Sau khi chuẩn bị cẩn thận </TIMEX3>

  <TIMEX3 tid="t1" type="DURATION" value="P1H" mod="MORE_THAN"> hơn 1 tiếng </TIMEX3>

It can be seen that our model, which integrates dependency parsing, successfully annotated the time span "Sau khi chuẩn bị cẩn thận (*After careful preparation*)". This is one of our improvements, as in Vietnamese, not only specific times but also phrases following words like "khi (*when*)", "sau (*after*)", "trong (*during*)", etc., are considered time expressions that need to be captured and annotated.

5 Conclusions

In this paper, we have presented a case study on the application of the ISO-TimeML annotation scheme to the semantic annotation of Vietnamese documents. We have introduced different examples of temporal and event expressions in Vietnamese and their annotation using ISO-TimeML entities and attributes. With the experiments conducted on large language models and our developed models, the results achieved are quite promising for both event and time annotation.

In the future, we will continue to refine the ISO-TimeML semantic labels for Vietnamese, specifically focusing on entity link tags. Additionally, we are still working on the semantic annotation of the Vietnamese translation of the book "The Little Prince" (Saint-Exupery). This annotation project allows us to explore various aspects of the semantic annotation framework ISO-SemAF in a comparative approach.

6 Acknowledgement

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Appendix

Table 5: Attribute "class" in Event.

English	Definition	Example
state	Circumstances in which something obtains or holds true.	He mediated the **crisis**.
reporting	Action of a person or an organization declaring something, narrating an event, informing about an event, etc.	No injuries were **reported** over the weekend.
perception	Physical perception of another event	Everyone could **hear** the man shouting loudly.
aspectual	Grammatical device of aspectual predication, which focuses on different facets of event history	All non-essential personnel should **begin** evacuating the sprawling base
I-action (Intensional Action)	Introducing an event argument describing an action or situation from which we can infer something given its relation with the I-action	They were **asked** to take along important papers.
I-state	States referring to alternative or possible worlds	"They don't **want** [to play with us]," one U.S. crew chief said.
occurrence	All of the many other kinds of events that describe something that happens or occurs in the world.	Mia **visited** Seoul to look me up yesterday.