"There's No Way I Would Ever Buy Any Mp3 Player with a Measly 4gb of Storage": Mining Intention Insights about Future Actions

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Abstract. In this paper we present a method for the automatic detection of user-stated intentions in terms of desires, purposes and commitments as specific insights deriving from the semantics of the intention expressions. The method is based on a linguistic data-driven and domain-independent framework for textual intention analysis and achieves substantial levels of accuracy in detecting future intention expressions and their structural components. Furthermore, we demonstrate several usage scenarios in the business intelligence context showing that the introduced insights can be interpreted from various perspectives and serve as variables in predictive or decision making models in any domain of interest.

Keywords: Social Media, Text Analytics, Intention Analysis, Future Intention, Desire, Purpose, Commitment.

1 Introduction

In this paper we focus on linguistically instantiated intentions about future actions expressed by an author of a text (e.g. Twitterer, blogger, Facebook user) and present a method for the automatic detection of desires, purposes and commitments as intention insights. Intention as "*the cognitive representation of a person's readiness to perform a given behavior*" is considered the immediate antecedent of human behavior [1]. Since intentions are intimately linked to behaviors, the ability to recognize and understand them is of critical importance for their correlation with KPIs, prediction and decision making in domains like business intelligence and national or cyber security, among others. Understanding users' intentions can provide business advantages like indicating potential customers, personalizing contents or displaying targeted commercials [9].

Intention Recognition (IR) -as the task of inferring an agent's intention by analyzing his/hers actions and their effects on the environment [13]- focuses on actions and given behaviors of an observed agent using logic-based formalisms and reasoning mechanisms [20]. Major application areas include assisted living, ambient intelligence, terrorism and computer system intrusion detection. Within the last decade

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considerable work has been done also in the domain of understanding users' intentions based on their web browsing and/or searching activity, i.e. a user's intention to purchase or participate in commercial services [9]. Another way to obtain such insights is to directly ask individuals to state their intentions; intentions data, that are in this case available through questionnaires or interviews, are being used as a prediction and decision making tool in several domains (e.g. prediction of election outcomes). In the business intelligence context purchase intentions are widely used as a measure for sales forecasting or evaluating promotions' effectiveness [24], among others. With the advent of Social Media (SM) and online fora people publicly voice their needs and plans without being asked to do so; stated intentions data are freely available in massive amounts providing new paths for intention research. However, the user-generated content has been scarcely explored from the IR standpoint. The palpable advantages of exploiting the availability of massive amounts of SM data for mining user-stated intentions are derived through a) the ability for low-cost and almost real-time monitoring of different kinds of intentions stated by multiple users (agents/survey participants) in any domain of interest, and b) the nature of the stated intentions: the Intention Holders (IH) are acting as users of a particular medium by freely expressing their thoughts and plans and not reacting as subjects of a particular survey. Thus user-stated intentions are not affected by the "systematic intention bias" [24] that underlies survey-stated intentions because the respondents may try to guess the correct answer or misunderstand the question. Furthermore, textual IR can be efficient in multiple ways, if combined with other types of information contained in the user-generated content (e.g., information about when or how the IHs are planning to achieve their goals) and/or extra-linguistic information available through SM analytics i.e. spotting users/agents of interest based on users' profile information (age, gender, location, education) and/or their influence (network statistics, communities).

The contribution of this paper is twofold: the first is a linguistically driven framework for textual intention analysis (section 3). The second is a precision-oriented method for the automatic detection of user-stated intentions and their structural components according to the proposed framework (section 4). The experimental evaluation of the proposed method has shown significant levels of accuracy in all types of the extracted information (section 5). This paper concludes with a demonstration of some usage scenarios of the intention insights in the business intelligence domain (section 6) and a discussion about future directions (section 7).

2 Relation to Prior Work

2.1 Theoretical Background

The mental content of intentions has been a subject of philosophical debate due to the different renditions it involves: intention as practical attitude marked by its pivotal role in planning for the future [5]; intention-with-which an action is done in terms of a primary reason in doing something [10]; intentional action in terms of acting for a reason [2]. In our work the notion of intention coincides with the first interpretation. Within the scope of language philosophy the notion of intention has been deployed in a multitude of ways in explaining speaker meaning [12] and speech acts [21, 22],

among others. A speech act is the basic functional unit of language used to express meaning. The Speech Act Theory [3, 21, 22] attempts to explain how speakers use language to accomplish intended actions and how hearers infer the intended meaning based on the assumption that each speech act expresses the speaker's intention to communicate certain content (e.g. ask questions, give directions, make statements) to some audience/addressee. Based on their content, speech acts are classified in a variety of types [6, 8, 17, 22]. In the present work, we focus on speech acts communicating future intentions, namely acts through which a writer of a text/message intends to communicate what he/she intends (thinks, plans or wants) to do in the future. In this regard, intention expressions as speech acts are only partially linked to the commissive speech acts of Searle's taxonomy [22], since they do not necessarily entail the commitment of the writer to some future action.

2.2 Computational Approaches

Future intentions have been studied within the scope of commissives in the broader context of speech acts classification of different kinds of text genres such as emails [8, 17], message boards [18] and chat rooms [25]. For example, authors in [18] treat plan expressions found in message boards as implicit commitments and create a feature for recognizing plan expressions such as "*I am going/planning/plan to*", excluding however decisions. In the work of [8], email messages are classified based on an ontology of verbs and nouns, which jointly describe the "email speech act" intended by the email sender; the "commit" class refers to messages committing the sender to some future course of action or confirming the sender's intent to comply with some previously described course of action, whilst the commitment aspect is included in "propose" messages e.g. emails suggesting a joint meeting. Desires about something to happen have been studied in terms of "wishes" in the work of [11], in the context of building wish detectors applied on datasets of product reviews and political comments, whilst finer-grained approaches like [19, 27] focus on purchase and suggest wishes in the product reviews domain. In the recent work of [6], SM users' intentions as speech acts are classified according to a novel ten-way classification schema (e.g. intention to criticize, wish or purchase) linking the intention analysis output with specific benefits in business functions (sales, marketing and customer service). The very idea of Intent Analysis in natural language text was introduced in [16], a work presenting a prototypical implementation of generating intent profiles of natural language text documents based on the social-psychological theoretical framework of [7] that organizes high-level intentions of people into 135 categories (e.g. Charities, Helping Others). Our task differs from approaches like [8, 17, 18, 25] in that our interest in limited to speech acts communicating future intentions yet not restricted to the content of commissives; focusing on user-generated content in SM and online fora, we present a novel fine-grained intention classification schema based on the semantics of the stated intentions rather than the type of the intended activity like in [6, 16]. From a methodological perspective, our work is closer to the rule-based method of [19].

3 Identifying User-Stated Future Intentions

Intention is examined in terms of linguistic expressions transmitting a writer's future intention (FI) as regards a plan, an aim or a desire about the future. Hopes and wishes are out of the scope of the present study. In this section we describe a linguistic data-driven framework for Textual Intention Analysis as the task of the automatic extraction of stated intentions from user-generated content using NLP (Natural Language Processing) techniques.

3.1 Datasets

To build the intention analysis framework presented in this section and the computational method described in section 4 we used the following datasets:

- SemEval 2014 ABSA[1] Task datasets consisting of 6092 sentences from the restaurant (3044 sentences) and the laptops (3048 sentences) reviews domains;
- WISH corpus [11] consisting of 7614 sentences from political discussions (6379 sentences with Web postings at politics.com) and product reviews (1235 sentences from Amazon.com and cnet.com);
- A corpus of 3000 tweets compiled using as keywords words used to express FIs (e.g. plan, want, purpose, aim).

We observed that FIs are highly domain dependent, i.e. purchase intentions (e.g. "*We'll return many times for this oasis in mid-town*") are common in the product and restaurant reviews domain, but unlikely to occur in the politics domain, and vice versa; vote intentions (e.g. *If she's the nominee however I will probably vote for her*") are frequent in the politics domain but not found in reviews. This coincides with the findings of [11] for wishes. As concerns the frequency of FI expressions, they are rare in the politics and reviews corpora. In the case of the product and restaurant reviews, negated FIs (e.g. "*I will never visit this restaurant again*", "*It was a total Dell experience that I will never repeat*") are more frequent than positive ones (e.g. "*My next computer will be a MAC*") serving as means to express negative sentiment. On the other hand, the domain-independent Twitter corpus contains plenty of FIs ranging from plans, thoughts and desires having to do with daily routine (e.g. "*I wanna buy a shovel #snowproblems*, "*Going to watch hangover 3 tonight*"), to life decisions (e.g. "*I'm seriously about to quit my job*", "*I'm thinking of going back to London*") or (repressed) emotions (e.g. "*I wanna buy Real Madrid*", "*One day I'm going to bang Ian*"), among others.

3.2 Further Observations and Analysis

FIs as Intended Meaning. Assuming that a user's *x* intended meaning is a purchase-FI *z* about a specific product *P*, here are some frequent types of examples expressing

[1] http://alt.qcri.org/semeval2014/task4/index.php?id=data-and-tools

z: a) *"I' m thinking of buying P", b)"Tomorrow I'm going to P-stores", c) "Do you know how much a P costs"?, d)"I want to buy P", e)"I want P"*. In (a) *x* states *z* for *P* in an explicit manner, whilst in (b-c) *z* may be inferred making the abduction: *x* wants P/ *x* intends to visit *P*-store/ *x* is interested for the price of *P*, hence *x* probably has a *z* for *P*. In (b) the explicitly communicated message is *x*'s intention to visit *P*-store, whilst in (c) is an inquiry about the price of *P*. Apparently *x* intends to visit *P*-store and asks for the price of *P* for a reason, which may be the actual intended message communicated indirectly through the specific utterances. Recovering *z* as the implied/indirect message involves, among others, knowing the (conversational) context i.e. (b-c) replying to questions/tweets like "*Have u bought/seen the new P yet*". However, depending on the context, (b) may as well entail other indirect messages i.e. going to *P*-stores in order to return/fix an already purchased *P*, whilst *x* may be uttering (c) with the implicit intend of discouraging someone else from buying *P* by implying that it is very expensive. In these cases *z* as the communicated meaning can be considered to be what is known as conventional implicatures [12], namely (acts of) meaning implying one thing by saying something else. In the present study we focus on utterances like (a), whereby a FI meaning is a product of deduction based on the logical consequence of what is being explicitly stated: "*x* states that *x* is thinking of buying P→ *x* intends to purchase P". In this respect explicitly stated future intentions can be defined in terms of "intended explicatures", namely assumptions developed from the "logical form" encoded by an utterance [23], where "logical form" is a semantically complete structured set of constituents. In the case of desires like (d-e), also included in the present work, depending on the utterance type, the FI meaning may be inferred deductively e.g. (d) or abductively e.g. (e).

FIs Expressions Structure. Explicit FIs utterances as "semantically complete structured sets of constituents" appear to follow a typical recurrent pattern irrespectively of the domain and the type of the FI (e.g. purchase or vote):

<Subject> + <Intention Lexical Unit(s) (ILU)> + <Object of FI>

Where

<Subject> belongs to {I, we, my, our}

< ILU> may be a verb, participle, adjective or noun instantiating the FI (e.g. thinking of, plan, promise, unavailable, willing, ...)

<FI Object> may be a verb instantiating the intended activity (e.g. buy, sell, change, vote, watch, ...} and/or a noun or nominal phrase instantiating the object of the activity (e.g. phone, car, house, Hangover 3, her,…)

An important aspect of FIs is their polarity: the subject may express his/her intention to perform (positive polarity) or not (negative polarity) a given activity; in other words, the object of the FI may be intended or not. A second important aspect of FIs is their probability to be realized as it can be derived from the semantics of their linguistic instantiations.

Probability as an Aspect of FIs and Intention Insights. Focusing on the semantics of the FI utterances we classify them into three semantic categories –i.e. intention insights– with regards to the confidence in which they are stated. Confidence is examined in terms of user's commitment to the communicated FI. Based again on user-generated content observations, we adopt a binary classification: a writer may simply state a purpose, aim or plan about a future activity e.g. ("*I'm thinking of buying a mp3 player*") or commit himself/herself to this future activity, e.g. ("*There is no way I would ever buy any mp3 player with a measly 4gb of storage*"). Finally, a third category stands for utterances expressing desires e.g. ("*I would like to have an mp3 player*"). Respectively, we use the terms PURPOSE, COMMITMENT and DESIRE to name the designated insights.

DESIRE does not involve a commitment to act [5] and is considered as a separate semantic class in that the FI meaning may be a product of abduction as opposed to explicitly stated plans and purposes. An important aspect of desires is that they may motivate a future plan or purpose [26]. Desires may range from simple needs and volitions to intense appetites. The PURPOSE category stands for expressions of plans, purposes or thoughts for future actions not providing any information about how likely it is that the user will actually perform the intended activity. Finally, COMMITMENT refers to expressions emitting the user's determination (promise or decision e.g. "*Of course I'll sell my iPhone"*) or obligations (e.g. *I have to go to the doctor tomorrow*) for a specific activity. The commitment aspect is usually instantiated through the semantics of the ILU (e.g. promise, swear) or through additional elements, such as high probability-strong confidence adverbs (e.g. definitely, of course), negation (e.g. there is no way, never) or temporal expressions referencing a specific time (e.g. *tomorrow, by the end of the week*).

The three-degree probability incorporated in the insights is qualitative rather than quantitative and results from the semantics of the intention predicates; it can be analyzed from various perspectives in correlation with different types of factors (behavioral, social, economic etc.) and thus have different interpretations depending on the domain and the intended activity. In section 6 we demonstrate several usage scenarios in the business intelligence context focusing on purchase intentions.

3.3 Intention Analysis Framework

The outcome of the above described types of analysis is the representation of FIs expressions as instantiations of a framework for textual intention analysis. The proposed framework can be formulated as follows:

"*An agent x expresses her/his intention i at a specific time t with some degree or confidence y to perform or not a future action z*".

Where

x is the user/writer of the text;
i is a desire, purpose or commitment;
y is the confidence of *i*;
t is the time of the statement expressing *i*;
z is the object of *i*.

The object values vary depending on the activity's nature and the domain (e.g. purchase, sell, suicide, attack, vote, support or participate intentions). Further analysis of the potential objects is out of the scope of this paper. Based on this formula, we built a rule-based method for the automatic detection of user-stated FIs described in the following section.

4 Methodology

The method for the automatic detection of FIs consists of (a) a data-driven lexicon (Intention Lexicon) of lexical items conveying intentionality (e.g. aim, attempt, inclined, choice, decision), and (b) a set of linguistic rules designed to detect intention expressions and their structural components (Intention Grammar - IG). Furthermore, the system integrates a Negators lexicon (e.g. no, any). For the preprocessing phase we use the resources of ANNIE[2]. The overall workflow is depicted in Figure 1.

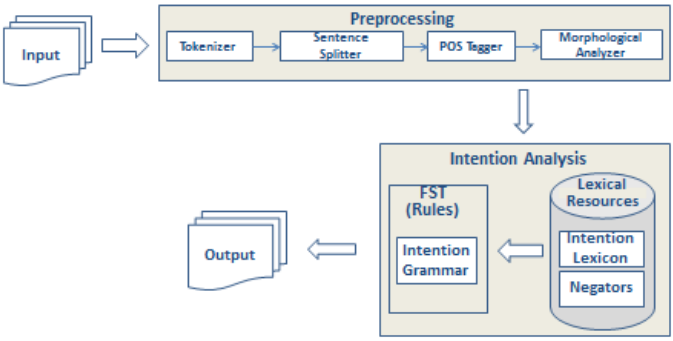

Fig. 1. NLP pipeline for Intention Analysis

Given an input text or text span, the illustrated NLP pipeline performs tokenization, sentence splitting, POS tagging and morphological analysis. The pipeline then detects and annotates in the input text the words or phrases that are contained as entries in the integrated lexical resources. Each detected lexicon entry is being assigned with the relevant metadata provided by the lexicon (see 4.1). Finally, the rules exploit the lexico-syntactic information incorporated in the metadata of IL in combination with contextual information by modelling shallow syntactic relations (see 4.2) in order to determine which spotted IL's entries are used by the author of the text (agent) to express FIs. IG returns as output the type and the object of each identified intention expression. The polarity of the intention is considered by default positive, unless it has been assigned the value "negated".

[2] http://gate.ac.uk/sale/tao/splitch6.html#chap:annie

4.1 Intention Lexicon

Intention Lexicon (IL) is a data-driven lexicon designed as the core component of IG in order to enable it to detect explicitly stated intention expressions in text. The lexicon was built upon a primary set of ILUs, namely terms conveying intentionality (e.g. want, will, plan, purpose, intend, goal, eager) and was then expanded manually using semantically related terms (e.g. synonyms, antonyms, troponyms) from Wordnet[3] and Wordnik[4]. Each entry is classified according to its syntactic category as VB (verb), MD[5] (modal verb), JJ (adjective or participle) or NN (noun) and assigned with a prior "desire", "purpose" or "commitment" semantic label. For the semantic classification of each entry we used information about its potential meaning from dictionaries and Framenet[6] [4] focusing, however, on the semantic content of the three insights. For example, in Framenet the lexical units "promise" and "will" are tied to the meanings of "commitment" and "desiring" semantic frames respectively. In our case "promise" is also classified in the "commitment" class but "will" is considered a "purpose" predicate. Entries conveying a negated polarity in their semantics (e.g. unavailable for, refuse) have been assigned a relevant label. Finally, intention verbs (VBi) and adjectives/participles (JJi) are further grouped into particular categories based on their syntactic behavior. Each category corresponds to a specific type of a syntactic complement:

1. Noun (VBi1, JJi1) e.g. I want a phone. I' m unavailable for the meeting on Friday.
2. Infinitive form of another verb (VBi2, JJi2) e.g. I am about/ willing to get a divorce.
3. Gerund (VBi3, JJi3) e.g. *I am thinking off/ intent upon going back to London.*
4. Verb (VBi4) e.g. I will visit this restaurant again.

The rationale behind this further classification is that a VBi or a JJi are likely to express a FI when followed by one or more of the above types of complements. A sample of the structure of IL is provided below in Table 1:

Table 1. Example of Intention Lexicon

Entry	POS	Insight	Syntactic group	Polarity
thinking of	VB	purpose	VBi3	-
plan	NN	purpose	-	-
want	MD	desire	VBi1, VBi2	-
unwilling	JJ	desire	JJi2	Negated
intent upon	JJ	commitment	JJi1, JJi3	-

[3] http://wordnetweb.princeton.edu/perl/webwn

[4] https://www.wordnik.com/

[5] We classify as Modal verbs (MD) also expressions like "have (got) to", which are closely related to modals in meaning and are often interchanged with them-, as well as informal types like "wanna" (want to), "gonna" (going to), "gotta" (have got to).

[6] https://framenet.icsi.berkeley.edu/fndrupal/framenet_search

4.2 Intention Grammar

Intention Grammar (IG) is a precision-oriented FST grammar aiming to detect FIs in text. It relies on IL and a manually built Negators lexicon. Given an input text, IG determines which spotted IL's entries express FIs -in terms of desires, purposes and commitments- based on sets of linguistic rules of shallow syntactic relations patterns that exploit the lexico-syntactic information incorporated in the metadata of IL and impose specific restrictions in the context around a candidate FI expression. In particular, IG contains three sets of rules: rules based on intention verbs, adjectives/participles and nouns respectively. Here are two examples of rules based on VBi:

Rule 1: << PP_1>> << Negator?>> << VBi4>> << Negator?>> <<VB>> <RB?> <to?> <DT?> <JJ?> <<NN>>

Rule 2: << PP_1>> <be?> <MD?> <<Negator?>> << VBi3>> << Negator?>> <<VBG>> <RB?> <to?> <<NN?>>

Where

PP_1 belongs to {I, we};
Negator belongs to Negators Lexicon;
VBi4 belongs to Intention Lexicon;
DT is a determiner {the, a, this,…};
JJ is any adjective;
NN is any noun;
VBG is any gerund;
RB is any adverb.

These rules match sentences containing the described patterns (The "?" is used for non-core elements, double "< >" stand for the core elements). For example, Rule 1 matches sentences like (a) and (b), whilst Rule 2 sentences like (c) and (d).

a) I (don't) have to buy a new phone.
b) I will go back to this (amazing) restaurant one day.
c) I am (not) thinking of switching to Mac.
d) I (may) consider moving back to London.

Rules 1 & 2 return as output the following information types for the specific examples:

- Insight type: "purpose" in all cases (a-d) as derived from the semantic labels of "*have to*", "*will*", "*thinking of*" and "*consider*" in IL.
- Polarity: if "*not*" or "*don't*" are activated in sentences (a) and (c), then they are assigned a negative polarity.
- Object of intention: "*buy*" and "*phone*" in (a), *"go back",* "*restaurant*" in (b), "*switching*" and "*Mac*" in (c), "*moving*" and "*London*" in (d).

5 Experimental Evaluation

To evaluate our method we ran a specific case study in the Customer Product Reviews domain using the dataset of [14, 15]; the dataset consists of approx. 4250 sentences - customer reviews of five products. We annotated it with intention-related labels according to the intention analysis framework using the GATE[7] platform. The evaluation results for each information type are illustrated in Table 2:

Table 2. Evaluation Results on Customer Reviews Dataset

	Recall	Precision	F-Measure
Intention	62%	80%	70%
Insight type	57%	74%	61%
Object_of_Intention	48%	82%	61%
Negated Polarity	55%	100%	71%

The results confirmed our expectations favoring a precision-orientated method, since IG achieves substantial precision in all types of the extracted information. The false positives that affect the precision of our results are mainly due to factors that the method is not yet designed to address, as for example the semantic content of the object of the intention i.e. in sentences like *"I will just say this: I will never go back to my archos again"* the rules correctly identify "*will just say this*" and "*will never go back…*" as intention expressions; however, in the first case the semantics of the object "say" cancel the FI meaning since in this context the particular expression is a prefatory statement. The low recall results are mainly due to the limitations of the shallow syntactic relations modelling, since long distance dependencies cannot be captured through a window of a limited number of Tokens i.e. for the sentence "*I have but plan on selling my rebel ti and all of the equipment with it*" IG returns as objects of the intention "selling" and "rebel ti", but cannot detect the object "all of the equipment". In the negated polarity class, the low recall is also due to negation expressions that are not included in our Negators lexicon yet i.e. *saved me from* (e.g. *"saved me from having to buy an expensive optical cable*").

6 Usage Scenarios

Assuming placing "purchase" as a value for the object of the intention, a company having access to the information contained in the above described framework automatically extracted from Twitter could benefit by a) getting a first-hand view of a new product launch or sale campaign i.e. measure impact in terms of how many people tweeted that they are thinking or have already decided to buy it, and b) reputation monitoring, i.e. negated intentions like "*I will never buy an x product again*", where x is the name of a particular brand, (re)tweeted by highly influential users (e.g. celebrities) can spread within a few only minutes and cause significant damage. Focusing on

[7] https://gate.ac.uk/

the three insights per se, here are some possible interpretations: a) Stating a purchase desire about something ('want it') instead of a purpose ('planning to buy it') may indicate that perhaps the potential customer cannot afford it. Subsequently, a large amount of purchase desires about a specific product correlated with low sales rates may indicate that a company may have to do something about the price. b) Purchase purpose instead of commitment may indicate that the potential customer is just shopping around i.e. a frequent type of purchase purposes is "*I'm thinking of buying x, any ideas/ opinions/ suggestions /alternatives/…*?. Depending on the value of "x" (own or competitive product) a company can customize accordingly its SM strategy. c) Purchase commitments can be correlated with sales rates.

7 Conclusions and Future Work

We presented a novel study of intentions from an NLP perspective involving a linguistic data-driven framework and method for textual intention analysis. Our notion of intention refers only to future actions and to the best of our knowledge our work is the first to introduce desires, plans and commitments as insights deriving from the semantics of intention expressions. The introduced insights can be interpreted from various perspectives and serve as variables in predictive or decision making models in any domain of interest, since the proposed framework is domain-independent. Future work includes evaluating our method on SM datasets, enhancing it with deep linguistic processing like dependency parsing and analyzing specific types of intended activities (i.e. purchase intentions).

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