Using NooJ for semantic annotation of Italian language corpora in the domain of motion: a cognitive-grounded approach

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Abstract

In this paper we propose a system to parse and annotate motion constructions expressed in Italian language. We used NooJ as a software tool to implement finite-state transducers in order to recognize linguistic elements constituting motion events. In this paper we describe the model we adopted for semantic description of events (grounded on Talmy's Cognitive Semantics theories) and then we illustrate how the system works with a domain-specific corpus, the structure of annotation that our system will perform, some annotation structures of example sentences expressing motion and then an attempt to evaluate the system's performance.

1 Introduction

The building of models of semantic knowledge to be implemented in language recognition and analysis systems shares some features with the theory of perception (Piotrowski and Palibina, 1973). In a Cognitive Linguistics paradigm this task should be viewed as the modelling of the human ability to map concepts onto syntactic-semantic constructs. The aim of this contribution is to describe an approach to the annotation of expressions of motion in Italian. The set of concepts (i.e. the semantic model) is grounded on a cognitive semantics theory where knowledge representation constitute both the basis of the construction process of meaning and also the goal of the proposed application. From the computational point of view we make use of recursive transition networks (RTNs) used for recognition and subsequent annotation of text with the domain's concepts. To implement RTNs we used NooJ development environment (Silberztein, 2004). We used NooJ because in this way we can easily write local grammars describing the elements to be recognized. From the technical point of view, at the dawn of NLP research on pattern recognition, experimentation started using the so-called rule-based paradigm. This entailed the processing of a large amount of grammar rules and the need of storage-consuming electronic dictionaries. These drawbacks caused these methods to be substantially impractical thus shifting rapidly the mainstream to the now widespread statistical corpus-based approach. In this paper we then propose a system that, using a cascade of transducers, deterministically recognizes semantic patterns describing motion events (Abney, 1996). These patterns show a large variety of diverse expressions and lexical choices (in one word lexicalization patterns) to describe motion. Such a variety is easily accounted for by a set of finite-state automata. The formalism used here to extract semantic components of the patterns is grounded on cognitive semantics theories attempting to describe the lexicalization processes that underlie the production of the syntactic and semantic structures expressing concepts related to motion and, consequently, to space.

2 Theoretical Framework

Spatial notions form the *kernel* of linguistic knowledge from which all other concepts are derived from, giving to the spatial knowledge a primary role on the conceptualization of the reality. This stance is called *localism*. Localism is the "*hypothesis that spatial expressions are more basic, grammatically and semantically, than various kind of spatial expressions [. . .] spatial organization is of central importance in human cognition*" (Lyons, 1977) and such approaches date back to the early comparative studies on prepositions and cases (Wüllner, 1827), where their meaning is viewed as grounded on spatial subjective intuition. Concepts related to space hold a basic role in the conceptualization process of the human's mind (and in child's development of con-

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cepts) and they serve as a major source of lexicalization of more abstract ones. These views regained importance with the rise of cognitive science in the 1970's, with the dominance of universalist studies on categorization. According to these theories, abstract concepts are thought to be derived from spatial primitives by using cognitive tools like *conceptual* metaphor (Lakoff, 1980) or derivation from universal representations like *image-schemata* (Johnson, 1987). Space-related constructs can thus refer also to a wider semantic area than just concepts closely related to space and motion: in this way a system extracting motion events will recognize also events other than motion-related ones, if expressed metaphorically with motion verbs. Sentences expressing motion events are generally characterized by a set of thematic roles from the semantic domain of concepts related to motion. Our purpose is to parse simple sentence constructs, more specifically we focus on compound nouns and predicate-argument structures, which bear most of the meaning (Surdeanu et al., 2003). Our final goal is to recognize the type of motion described and to semantically annotate the text with the related concepts.

3 The proposed system

The system implements semantic role labeling techniques (Gildea and Jurafsky, 2002) to parse predicate-arguments structures. Lexical constructs are connected to their corresponding roles selected by the verb. These latter will be recognized and annotated with their respective information elements related to the motion event. Predicate-argument structures are constituted by a main verb and a set of nouns or prepositional phrases specifying the meaning of the verb, which works as the head of the structure. Semantic model maps lexical elements into their respective semantic roles. In the following section we will describe the model we used for structure detection and annotation, we then detail the mapping layers implemented according to the annotation to be performed and finally we will illustrate some of the transducers used for the recognition of lexical elements and also we give some examples of possible practical uses of our system.

3.1 Semantic model of the motion event

To choose a suitable representation of motion events we need to consider different semantic roles expressed by lexical elements in order to map the predicate-argument structures onto elements of the semantic model of the event (Exner and Nugues, 2011). The model is thus constituted by a set of domain-specific semantic roles belonging to motion. To choose them we have considered the notion of *motion event* as introduced by Talmy (1985) where motion events are described as "*situation containing movement or the maintenance of a stationary location [. . .]. The basic motion event consists of one object (the Figure) moving or located with respect to another object (the reference-object or Ground)"*. Talmy's approach is based on perception and on neuropsychological theories: *Figure* and *Ground* are, for example, concepts borrowed from the so-called *Gestalt Theory*, a theory of mind opposed to structuralist and behaviorist approaches aiming to describe the mind/brain through holistic, analog and emergent mechanisms. This has led to choose a semantic model that is both cognitive-grounded and comprehensive of all necessary conceptual elements (Mosca, 2010). In Table 1 are listed the elements we choose to extract. As Italian is a pro-drop language, subject is often omitted and then FIGURE is seldom lexicalized.

Element	**Description**
FIGURE	The object that moves or is located with respect to another object.
GROUND	The reference object with respect to with the motion takes place or another object is located to.
SOURCE	The place where the described motion event starts.
GOAL	The place where the described motion event ends.
DIRECTION	The relative direction taken with respect to a ground or reference point (as *left, right, north, west, ...*).
VECTOR	The axis along which the motion take place and/or the absolute direction of the moving element.
PATH	The type of path performed by the moving element involving a ground element (*inwards, outwards, crossing, passing through*).
SHAPE	The shape of movement performed. (*circular, straight, curvilinear*)
PROXIMALITY	The distinctive feature of motion with respect to a ground or reference point (*near, along or throughout*)
MANNER	The manner of performed motion (*walking, running, wandering,...*)

Table 1: Elements of motion

3.2 Description of the system

The elements previously listed constitute the set of semantic roles of our model. They can be beared by the verb itself or explicitly lexicalized as syntactic elements of the sentence as direct objects, indirect objects or adverbial phrases (i.e. they are *satellites* of the verb). We need to implement a set of lexico-syntactic transducers to parse every single semantic elements.According to Mosca (2010), motion event sentences can be grouped in eight syntactic patterns with increasing analyticity. For our purposes we select the following ones:

1. Motion verbs that can stand alone with no adjoints.
2. Motion verbs accepting a noun phrase as direct object.
3. Motion verbs accepting a prepositional phrase as object.
4. Motion verbs expressed with a generic motion verb with prepositional phrases(s) plus one or more satellites to specify motion event roles.
5. Motion events analytically expressed with support verbs[1]

Verbs of the first type bear a lot of information and accept none or few satellites: according to Talmy's terminology they *conflate* semantic elements. A verb like *fiancheggiare* "conflates"all the information about the fact that a figure is moving in proximity to a reference ground. Conflation is "*any syntactic process [...] whereby a more complex construction turns into a simpler one.*" (Talmy, 2000). More analytic verbs bear few information and devolves their meaning to their *satellites*[2]. Satellites are lexicalized with different syntactic constructs. Our system recognizes locative adverbial phrases representing position or direction, deictic elements expressing proximality or distality (frequently referred to a reference ground) and so on. The system also maps satellites to the corresponding semantic roles and "deflates" the meaning of the verbs making it explicit.

Motion verbs are grouped in *semantic clusters* according to their meaning (Mosca, 2007). For each cluster we need to implement a set of transducers. We have considered motion verbs with the meaning of a generic motion from and/or to a ground object, verbs indicating a continuing motion along the same direction (called *source-destination verbs*), verbs indicating motion along a direction or towards something that specifies the followed path (*direction verbs*), verbs with the meaning of passing beyond, crossing, exiting or entering a ground, or with the meaning of moving along a direction or near a ground (*path verbs*), verbs indicating a proximal motion passing near a ground (*proximity verbs*), verbs specifying the shape of a path (curvilinear, circular, straight, etc.) (called *shape verbs*) and verbs that specifies the manner of motion (*manner verbs*).

Semantic patterns are represented with formalisms involving lexical, syntactic and semantic elements (*local grammars*) implemented on NooJ [3]. Local grammars are formal descriptions of morpho-syntactic and/or semantic regularities represented with finite-state transducers (Harris, 1991; Gross, 1993).

3.2.1 Annotation layers

The annotation is performed using a cascade of transducers. Parsing is done incrementally: annotations at one level make use of the ones performed on previous levels. We have implemented seven different layers, each defined by the type of structure(s) recognized, as described below.

Simple compound nouns This layer recognizes compound nouns with patterns like *N+Adj* (e.g. *lago blu*), *Adj+N* (e.g. *nuovo sentiero*), *N+N* (e.g. *piazza Garibaldi*, *N+Prep+N* (e.g. *casa di pietra*). These listed above are the most frequent patterns in Italian (Voghera, 2004). Below is reported the corresponding local grammar reported in NooJ's format[4].

```
SC::= NA | AN | NPN | NPV | NN | NeN
AN::= <A> <N>
NA::= <N> <A>
NPN::= <N> P <N>
NPV::= <N> (a|da|per) <V+Inf>
NN::= <N> <N>
P::= (di|a|da|in|con|su|per|tra|fra) <DET>*
```

Complex compound nouns The second layer refers to complex compound nouns: this layer recognizes compound nouns corresponding to forms as *strada ripida sterrata, bivio segnalato da bolli gialli, casa vicino all'incrocio di tre strade, versante occidentale della catena montuosa*. The head can be one of the cases listed

[1]Support verbs are constructions where the predicative role is taken by the noun (object) and the verb lose its meaning as *fare una curva VS curvare*

[2]They are "*the grammatical category of any constituent other than a noun-phrase or prepositional phrase complement that is in a sister relation to the verb root* "

[3]NooJ standard dictionary with other resources for Italian are developed and maintained by Simonetta Vietri of Università di Salerno and are available at *http://www.nooj4nlp.net/pages/italian.html*. (Elia and Vietri, 2002).

[4]Angle brackets denote a POS element of standard dictionary and asterisk refers to optional elements.

above and the modifier can be an adjectival or a prepositional phrase. Corresponding transducers are shown in Figure 1 and below is presented the related local grammar. As the former, this layer recognizes structure type, number, gender and head of the extracted nouns.

```
CCN::= (<N>|SC> (A_modifier | P_modifier | N_modifier))
A_modifier::= <AVV>* <A> ((e|ed) <A>)*
P_modifier::= P ( (<V+Inf>|<AVV>*)|(<N>|SC) )
N_modifier::= N
```

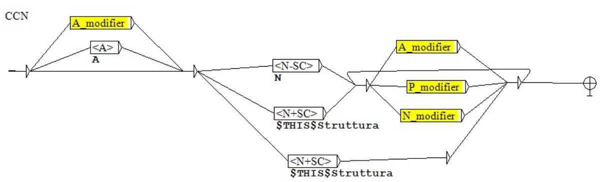

Figure 1: Transducer recognizing complex compound nouns

Noun phrases This layer annotates noun phrases and extracts their head. Transducer is shown in Figure 2.

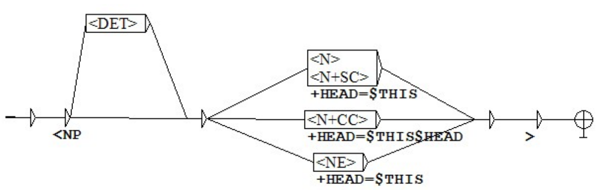

Figure 2: Transducer recognizing noun phrases

Prepositional phrases This layer annotates prepositional phrases and extracts their prepositional head and the dependent noun (or noun phrase). Respective transducer is shown in Figure 3.

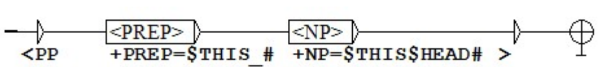

Figure 3: Transducer recognizing prepositional phrases

Motion verbs This layer recognizes motion verbs. The ones recognized by our system are extracted from a list compiled through a statistical analysis of a corpus of spoken Italian. This corpus was collected from experiments for which the goal is to solve a spatial description task. Verbs forming this list are a set of frequently used verbs while describing motion events in Italian. We adopted the classification and the set of lemmas proposed in Mosca (2007). The local grammar that recognizes motion verbs is reported in Figure 4. Transducers are shown in Figure 5.

```
MOTION-VERBS::=V-SD-GEN |V-SD-A|V-SD-CONT|V-SD-DA
        |V-SD-CONT|V-DIRECTION-GEN|V-DIRECTION-BACK
        |V-DIRECTION-DEV|V-DIRECTION-DOWN|
        |V-DIRECTION-UP|V-PATH-THROUGH|V-PATH-IN
        |V-PATH-OUT|V-PATH-ACROSS|V-PROXY-NEAR
        |V-PROXY-ALONG|V-PROXY-OVER|V-SHAPE-CIRC
        |V-SHAPE-CURV|V-SHAPE-STRAIGHT|V-MANNER
V-SD-GEN::=<andare>|<tornare>|<venire>|<spostarsi>
V-SD-A::=<arrivare>|<giungere>|<raggiungere>|<trovare>
             |<incontrare>|<finire>|<trovare>|<sbattere> contro|
          |<trovarsi>|<fermarsi>
V-SD-CONT::=<andare> avanti|<continuare>|<procedere>
       |<proseguire>
V-SD-DA::=<partire>
V-DIRECTION-GEN::=<puntare>|<riandare>|<tenere>|<avvicinarsi>
                         |<dirigersi>|<inoltrarsi>|<muoversi>
         |<tenersi>
V-DIRECTION-BACK::=<tornare> indietro
V-DIRECTION-DEV::=<abbandonare>|<inclinare>|<piegare>
         |<scansare>|<rientrare>|<abbassarsi>
         |<allargarsi>|<alzarsi>|<inclinarsi>
V-DIRECTION-DOWN::=<discendere>|<scendere>
V-DIRECTION-UP::=<salire> su*
V-PATH-THROUGH::=<attraversare>|<incrociare>|<intersecare>
       |<tagliare>
V-PATH-IN::=<entrare>|<infilare>|<imboccare>|<prendere>
      |<immettersi>
V-PATH-OUT::=<sbucare>|<uscire>
V-PATH-ACROSS::=<passare>|<percorrere>|<seguire>
V-PROXY-NEAR::=<rimanere>|<lasciare>|<sfiorare>
V-PROXY-ALONG::=<costeggiare>|<rasentare>|<sfiorare>|<seguire>
V-PROXY-OVER::=<oltrepassare>|<saltare>|<sorpassare>|<superare>
V-SHAPE-CIRC::=<accerchiare>|<aggirare>|<cerchiare>
       |<circondare>|<circoscrivere>|<circumnavigare>
V-SHAPE-CURV::=<curvare>|<girare>|<svoltare>|<virare>
       |<voltare>
V-SHAPE-STRAIGHT::=<tirare>|<proseguire>|<andare>
         |<continuare>
V-MANNER::=<camminare>
```

Figure 4: Grammar recognizing of motion verbs

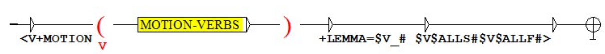

Figure 5: Transducers recognizing motion verbs

Verb phrases This layer recognizes different syntactic realizations of motion verb phrases distinguishing between active and passive form. The corresponding transducer is shown in Figure 6.

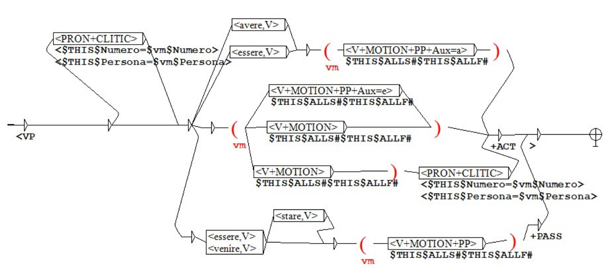

Figure 6: Transducer recognizing verb chunks

4 Motion Events' elements recognition

The two upper layers (i.e. the last processed ones) are used for recognizing the different elements of motion event: the first is dedicated to the recognition of satellites. They consist mainly of prepositions expressing information about motion (Mosca, 2012) such as Prepositional Case-Markers (PCM) and satellites-prepositions. Prepositional Case-Markers are prepositions with a weak or no meaning that serve to introduce a prepositional phrase as in *salire* ***su*** *sul tetto*. Satellite-preposition *Satpreps* are intended as prepositional particles fulfilling both the functions described before. For our purposes we have distinguished the following satellite types:

- DIRECTION: satellites expressing direction. They can be specified using an absolute or an intrinsic frame or reference Levinson (2003) (as *in direzione est* or *a destra*). The system also recognizes deictic relative reference grounds to/from an *origo*[5].
- POSITION: satellites expressing locations with an absolute or relative reference as *di fronte, a destra, sopra sotto, a est, qui, l.*
- PROXIMITY: satellites expressing *proximality*, i.e. object located in areas expressed with respect to a ground (*lungo, accanto, di fianco, nei pressi, vicino*).
- STRAIGHT: satellites expressing motion events in which the taken direction is straight (as *dritto*).
- CIRCULAR: satellites expressing motion events where the motion is circular (as *intorno,attorno*).
- THROUGH: satellites expressing motion events whose GOAL is reached via a path (as *attraverso*) or through a reference ground (as *in fondo, a fine*).

These transducers recognize FIGURE and GROUND elements, satellites and PCM (see Figure 7).

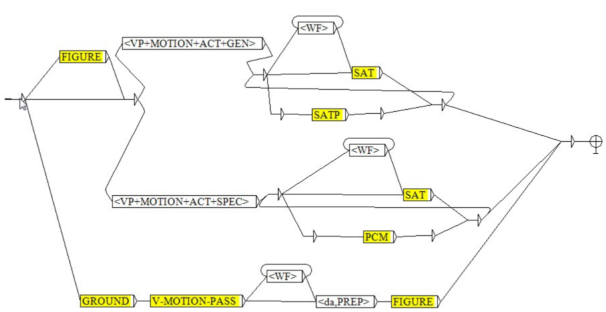

Figure 7: Transducers for recognizing satellites, figure, ground, PCM and Satpreps elements

We have also distinguished five types of lexicalization structures according to the meaning of the verb:

1. Structures expressing a generic motion with a source and/or a destination explicitly expressed.

<table>
<tr><td>Layer 1</td><td><N></td><td>+SC</td></tr>
<tr><td>Layer 2</td><td><N></td><td>+CC</td></tr>
<tr><td>Layer 3</td><td><PP></td><td>+PREP=preposition +DET + NP=noun_phrase</td></tr>
<tr><td>Layer 4</td><td><NP></td><td>+HEAD</td></tr>
<tr><td>Layer 5</td><td><V></td><td>+LEMMA=lemma
+(SD_GEN|SD_A|SD_DA|SD_CONT|DIRECTION_GEN|DIRECTION_BACK|
|DIRECTION_DOWN|DIRECTION_UP|DIRECTION_DEV|PATH_IN|PATH_OUT|
|PATH_ATTR|PATH_PER|SHAPE_CURV|SHAPE_CIRC|SHAPE_STRAIGHT
|MANNER)
+TERM</td></tr>
<tr><td>Layer 6</td><td><VP></td><td>+ACT | +PASS (+AUX=essere|avere)</td></tr>
<tr><td>Layer 7</td><td><SAT></td><td>(SATP | PCM
| SAT
+DIR (
+ABS +DIRECTION=(NORTH|NORTHEAST|SOUTH|SOUTHWEST|WEST|NORTHEAST)
| +REL +DIRECTION=(RIGHT|LEFT|BACKWARD|FORWARD|UPWARD|DOWNWARD
|OUTWARD|INWARD)
| +DEICTIC +DIRECTION=(TO_ORIGO|FROM_ORIGO|TO_GROUND))
+POS (
+ABS +POSITION=(NORTH|NORTHEAST|SOUTH|SOUTHWEST|WEST| NORTHEAST)
| +REL +POSITION = (FRONT|BACK|LEFT_FROM|RIGHT_FROM|ON|UNDER|INTO
|OUT_FROM)
| +DEICTIC +POSITION=(NEAR_ORIGO|FAR_FROM_ORIGO))
+CIRC
+PROXY=(NEAR|OVER|ALONG)
+STRAIGHT
+THROUGH +THROUGH_GROUND</td></tr>
<tr><td>Layer 8</td><td><ME></td><td>+SD (+TO |+FROM | +CONT)
+GROUND
+SOURCE
+GOAL
+PATH=(CROSSING|INTO|OUT_FROM|THROUGH)
+SHAPE=(CIRCULAR|CURVILINEAR +ENABLEMENT|STRAIGHT|custom)
+FIGURE_POSITION=<SAT+POSITION> +CHANGE_VECTOR
+VECTOR=(BACKWARDS|UPWARDS|DOWNWARDS)
+DIRECTION=<SAT+DIRECTION>
+PROXIMITY +PROXY_TYPE=(PASS|NEAR|ALONG)
+MANNER=manner</td></tr>
</table>

Figure 8: Annotations performed by our system

2. Structures describing a movement in a particular direction and/or along a particular vector. The direction can be expressed by a conflation of the directional element of meaning in the verb root (as in *scendere, salire, indietreggiare*) or by a satellite.
3. Structures expressing a motion along a path where the moving element can enter, exit, pass over or going through a the reference ground (verbs as *entrare, attraversare, percorrere, sbucare*).
4. Structures expressing proximal motion. We distinguish a motion along (*costeggiare, seguire*), near (*sfiorare, toccare*) or passing through a GROUND (*sorpassare, superare*).
5. Structures expressing a straight or round shape of the motion path. A round path can be a complete circular loop, a circle arc (*circoscrivere, aggirare*) or a curved trajectory as in *curvare, svoltare*. Note that in this latter case the motion will change vector so the system will note this explicitly with a dedicated annotation (+VECTOR_CHANGE).

Note that if the elements about motion are conflated in the verb root the information should be extracted by putting an empty-string transducer before the matching element with the desired annotation in output (see Figure 9).

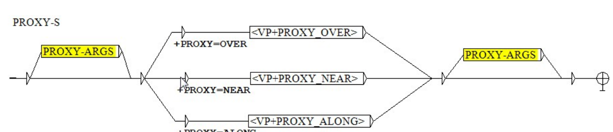

Figure 9: Example of a transducer recognizing motion elements lexicalized in verb root

Arguments of the verbs are extracted with the transducer shown in Figure 10. Elements lexicalized by satellites are extracted using transducers as the one shown in Figure 11. These latter have been designed according to the structure of related verb(s).

[5] With respect to Levinson (2003) we use here a slightly different terminology adopting the term *relative* for an intrinsic frame of reference in Levinson's sense and the term *deictic* for Levinson's relative frame of reference to express a direction with respect to a reference point or ground object

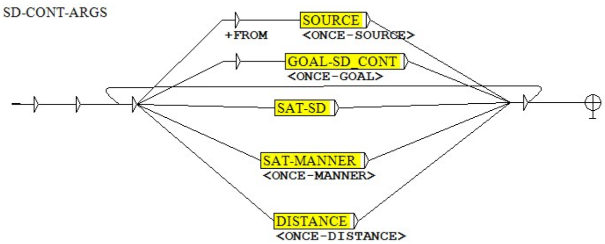

Figure 10: Example of a transducer recognizing motion structures arguments

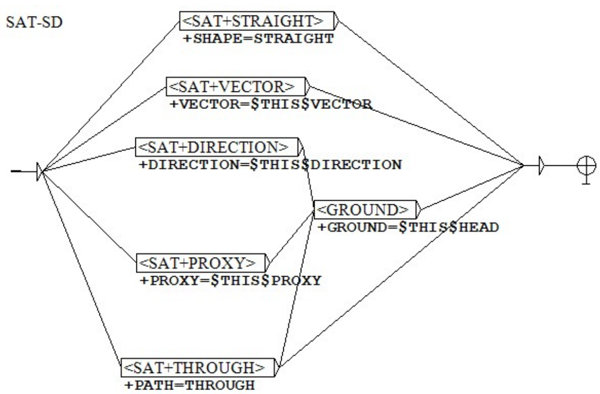

Figure 11: Transducer recognizing motion elements lexicalized in satellites

Transduction is performed when we need to annotate text chunks: annotation is given in the NooJ's XML-like form, i.e. using a node-label and a series of attribute-value pair specifying motion elements. Annotation and extraction are done simultaneously for every stage of the transducers' cascade. A comprehensive list of the annotations performed by our system is shown in Figure 8 where, for every layer, the annotation tree is detailed (annotations introduced by the standard dictionary are not reported).

4.1 Source-destination

These automata describe basic motion events (annotated as +SD) starting from a SOURCE and ending in a GOAL. These can be described by verbs as *andare, venire, spostarsi, tornare*. SOURCE and GOAL can be of different types: we have considered the following three cases:

1. The simplest case where the SOURCE and/or the GOAL are reference grounds expressed with prepositional phrases as *partire da casa* or *andare a casa*.

2. The case where the SOURCE and/or the GOAL are areas defined with respect to a reference ground as in *parti davanti la stazione*. The GOAL can be reached via a path or through a reference ground (*spostarsi in fondo al viale, andare alla fine della strada, partire da davanti la stazione*).

A generic motion should be expressed with a verb whose meaning focuses alternatively on different phases of the event as the reaching of a point or a place (+TO), the leaving from a point or a place (+FROM) as in *partire* or the continuing (+CONT) of the motion along a path as in *proseguire, continuare, andare avanti*. The system also distinguishes from terminative verbs +TERM involving the reaching of a goal (*raggiungere, arrivare, giungere*) or the reaching of a generic point along a translation process (*ritrovarsi, incontrare*). Examples of extracted structures are shown in Figure 12.

SD

Motion event construction	Related annotation
[...] si raggiunge il colletto sottostante.	<ME +SD+TO+GOAL=colletto sottostante>
la mulattiera proseque a destra [...]	<ME+FIGURE=mulattiera+SD+CONT+DIRECTION=RIGHT>
spostandosi alla destra verso un lungo contrafforte davanti al versante ovest	<ME+SD+DIRECTION=RIGHT+DIRECTION=TO_GROUND+GROUND=lungo contrafforte+FIGURE_POSITION=FRONT+GOAL=davanti al versante ovest
partendo dalla destra del parcheggio [...]	<ME+SD+FROM+TO+SOURCE=destra del parcheggio>
[...] si ritrova il passaggio	<ME+SD+TO+GOAL=passaggio>
Arriviamo sotto un ultimo gradino [...]	<ME+SD+TO+FIGURE_POSITION=UNDER+GOAL=ultimo gradino>
[...] si incontra il Ru de Montjovet	<ME+SD+TO+GOAL=Ru de Montjovet>
[...] si proseque a destra verso il bivio	<ME+SD+CONT+DIRECTION=RIGHT+DIRECTION=TO_GROUND+GROUND=bivio
[...] si proseque a sinistra attraverso una umida valletta verso un saliscendi boscoso	<ME+SD+CONT+DIRECTION=LEFT+PATH=THROUGH+GROUND=umida valletta+DIRECTION=TO_GROUND+GROUND=saliscendi boscoso>
[...] si continua verso i pendii superiori [...]	<ME+SD+CONT+DIRECTION=TO_GROUND+GROUND=pendii superiori>
[...] si proseque dritto	<ME+SD+CONT+SHAPE=straight>

Figure 12: Samples of source-destination structures with related annotations

4.2 Path

The system distinguishes four types of paths (+PATH), involving four different configurations of the motion:

1. A motion event which PATH entails that the FIGURE moves THROUGH a GROUND. The reference ground can be a road, a trail or a path (verbs as *passare, percorre, seguire*).

2. A motion event in which the FIGURE goes ACROSS a GROUND element (i.e. a river, a crossing, a wood). It can be described by verbs as *incrociare, tagliare, attraversare*.

3. A motion event in which the FIGURE *enters* in a GROUND element as a house, a road or a new path. It is described by verbs as *entrare, imboccare, immettersi* (INTO).

4. A motion event in which the FIGURE *exits* from a GROUND element (verbs as *sbucare, uscire*) (+OUT_FROM).

Examples of annotated structures are shown in Figure 13.

PATH

Motion event construction	Related annotation
[...] percorri il sentiero a destra per il laghetto	<ME+PATH=THROUGH+PROXY=ALONG+GROUND=sentiero+DIRECTION=RIGHT +TO+GOAL=laghetto>
[...]imboccare a sinistra una strada	<ME+PATH=INTO+CHANGE_VECTOR+DIRECTION=RIGHT+GROUND=strada>
Il sentiero, ora pianeggiante, percorre il bordo di una conca sassosa.	<ME+FIGURE=sentiero+PATH=THROUGH+PROXY=ALONG +GROUND=bordo di una conca sassosa>
[...] si entra nel desolato vallone	<ME+PATH=INTO+GROUND=desolato vallone>
[...] si sbuca fra i ripidi prati	<ME+PATH=OUT_FROM+GROUND=ripidi prati>
[...] attraversato a sinistra un piccolo greto	<ME+PATH=ACROSS+DIRECTION=LEFT+GROUND=piccolo greto>
[...] tagliando il ripido versante di conifere	<ME+PATH=ACROSS+GROUND=ripido versante di conifere>

Figure 13: Samples of path structures with related annotation

4.3 Proximality

The system extracts motion events' structures where the FIGURE moves near a GROUND object (+PROXY). We call this feature *proximality*. Transducers extracting these structures are shown in Figure 9 and examples of annotated structures are shown in Figure 14. Our system distinguishes three cases:

1. The case in which the FIGURE passes NEAR a GROUND object (verbs as *rimanere, sfiorare, toccare*).

2. The case where the FIGURE moves ALONG a reference GROUND (as a border). (as verbs *costeggiare, fiancheggiare*).

3. The case where the FIGURE passes OVER a reference ground (overstepping an obstacle or moving beyond a landmark). This is expressed with verbs as (*oltrepassare, superare*).

PROXIMITY

Motion event construction	Related annotation
[...] oltrepassato un canale di frana [...]	<ME+PROXY=OVER+GROUND=canale di frana>
[...] si lasciano a sinistra le Baite di Rocher	<ME+PROXY=NEAR+DIRECTION=RIGHT+GROUND=Baite di Rocher>
[...] costeggiando sulla destra un rado boschetto [...]	<ME+PROXY=ALONG+DIRECTION=RIGHT+GROUND=rado boschetto>

Figure 14: Samples of proximality structures with related annotation

4.4 Direction

The system recognizes five different cases in respect to the lexicalization of DIRECTION and VECTOR features of motion:

1. The case where the FIGURE has to go back (+DIRECTION_BACK) in respect to the direction already taken (+VECTOR=BACKWARDS). Event is described by verbs like *tornare (indietro), indietreggiare*.

2. The case (+DIRECTION_DOWN) where the FIGURE moves downwards (+VECTOR=DOWNWARDS) (verb *scendere*).

3. The case (+DIRECTION_UP) where the FIGURE moves upwards (verb *salire*).

4. The case (+DIRECTION_DEV) where the FIGURE changes direction (+CHANGE_DIRECTION) (verbs as *abbandonare, inclinarsi, rientrare, alzarsi*). This case can involve the change of direction and/or vector of the FIGURE.

5. The case (+DIRECTION_GEN) where the direction of the FIGURE is explicitly expressed by a generic verb (as *punta, dirigiti, muoviti*) using a direction satellite with respect to a reference ground. The system recognizes the case where DIRECTION is taken toward a reference ground (+DIRECTION=TO_GROUND).

Examples of annotated structures are shown in Figure 15.

4.5 Shape

There are also cases where the motion involves a straight or a circular movement (+SHAPE). The motion can take place with respect to a GROUND following a circular trajectory (verbs *aggirare, circondare, circoscrivere*) or just a direction change, usually with a turn (verbs *girare, curvare, svoltare*). Examples are shown in Figure 16.

DIRECTION

Motion event construction	Related annotation
[...] tornati in casa [...]	<ME+DIRECTION_BACK+VECTOR=BACKWARDS+TO+PATH=INTO+GOAL=casa>
[...] si punta verso un alpeggio in alto sotto la dorsale	<ME+DIRECTION_GEN+DIRECTION=TO_GROUND+GROUND=alpeggio> +VECTOR=UPWARDS+TO+FIGURE_POSITION=under+GROUND=dorsale>
[...] dal fondo del parcheggio si sale alla destra verso i dolci pendii	<ME+DIRECTION_UP+FROM+SOURCE=fondo del parcheggio +VECTOR=UPWARDS+DIRECTION=RIGHT+PATH=THROUGH +GROUND=dolci pendii>
[...] torna indietro attraverso il sentiero grande	<ME+DIRECTION_BACK+VECTOR=BACKWARDS+PATH=THROUGH +GROUND=sentiero grande>
[...] piegando a sinistra [...]	<ME+DIRECTION_DEV+CHANGE_VECTOR+DIRECTION=LEFT>
la traccia scende verso le costruzioni abbandonate	<ME+FIGURE=traccia+DIRECTION_DOWN+VECTOR=DOWNWARDS+TO +GOAL=costruzioni abbandonate+DIRECTION=TO_GROUND>

Figure 15: Samples of direction structures

SHAPE

Motion event construction	Related annotation
[...] si volge a destra [...]	<ME+SHAPE=CURVILINEAR+CHANGE_VECTOR +DIRECTION=RIGHT>
[...] la strada vira a sinistra [...]	<ME+FIGURE=strada+SHAPE=CURVILINEAR+CHANGE_VECTOR +DIRECTION=LEFT>
[...] aggirati alcuni valloni secondari [...]	<ME+SHAPE=CIRCULAR+GROUND=alcuni valloni secondari>

Figure 16: Samples of extracted shape structures

5 Evaluation of the system

In order to evaluate our system we have collected a corpus of about 300 texts describing hiking tours in Western Alps. Texts are extracted from hiker's fan websites (our main source was the site *http://www.inalto.org*).

These descriptions, from the point of view of language variation determined by the medium of communication, share characteristics both of written and spoken language. This is due to the distinctive traits of Web-Mediated communication where the language, although written, shows features of spoken language and also to the reduced perceived distance between addresser and addressee. Route descriptions posted in a blog brings similar characteristics: in this way we can easily have a corpus positioned "half-way" along the *diamesic* dimension (Mioni, 1983).

A hiking tour description, also, contains motion events where all three space dimensions are involved while describing paths. These can run up and down, going along grounds elements with directions that can be expressed lexically through both absolute or relative frames of references. All these features make hiking descriptions a well suitable test corpus for the system.

The dimension of our corpus is around 100kwords with a type/token ratio of 8%. In Table 2 we show the score of the system tested on the evaluation corpus at the current stage of development.

Precision	Recall	F1 score
70,5%	80,4%	75,1%

Table 2: System's scores

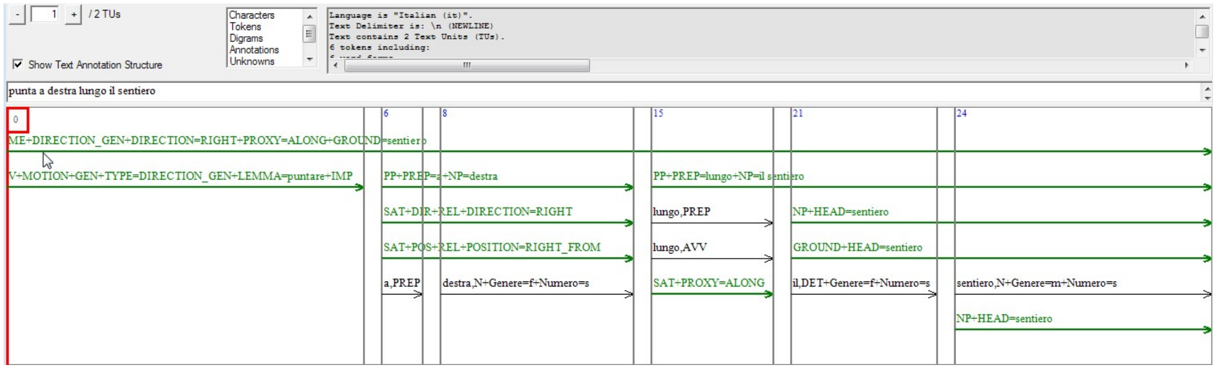

Figure 17: Annotation structure of a sample sentence

The evaluation is conducted on recognized sentences not taking into account the annotation structure. We show in Figure 17 a sample of the annotation structure of a sample sentence.

The proposed system can be used to extract motion structures with complex combines of features. Here we extract events involving a changing vector to left (see Figure 18):

<ME+CHANGE_VECTOR+DIRECTION=LEFT>

Text	Before	Seq.
ESC_1_060.not		imboccare sulla sinistra la Via S
ESC_1_139.not		si imbocca a sinistra un più largo
ESC_1_192.not		Il sentiero volge a sinistra
ESC_1_360.not		si svolta a sinistra iniziando
ESC_1_403.not		si imbocca a sinistra una pista ombrosa
ESC_1_417.not		prendere a sinistra un sentiero fra i prati
ESC_1_498.not		la strada vira a sinistra

Figure 18: Samples of extracted motion structures

Our system can also make queries using lower annotation layers as in:

<V+SD_CONT> <PCM+PREP=su> <GROUND>

where the system extracts all motion events in which the FIGURE continues along a PATH expressed by a GROUND and introduced by the preposition *su* (on) used here as a case-marker. Results are shown in Figure 19.

6 Conclusions and future work

We have described here a system that recognizes sentences expressing motion events and annotates them extracting the information about the type of performed motion. This information is gathered from the meaning of the verb and explicitly lexicalized by verb's satellites expressing motion features such as position, direction or shape. Elements participating in motion process are annotated according to concepts borrowed from psychological theory of Gestalt as used in Talmy's theory of motion events. It would be possible to expand the scope of our system making it able to recognize more complex and longer patterns of expressions. We could also make use of lexico-syntactic constraints in order to filter out relevant sentences and thus improve precision. Thanks to the integration capability of NooJ our system is designed to be also part of more complex applications in a NLP pipeline. As an example, it is possible to use the information extracted and reported on annotation layers to populate an ontology in the domain of space or motion (Salza, 2013). Moreover, the described system can be extended to recognize a large variety of lexical structures; among these, the vocabulary related to manner of motion lacks a deeper theoretical analysis and requires further work.

Text	Before	Seq.
ESC_1_050.not		prosegue sulla pista asfaltata
ESC_1_084.not		prosegue sulla traccia di una mulattiera
ESC_1_119.not		prosegue sul largo crinale sempre più roccioso
ESC_1_121.not		Proseguendo sul filo della cresta sommitale
ESC_1_124.not		prosegue sul panoramicissimo crinale prativo
ESC_1_128.not		prosegue sul filo della cresta
ESC_1_129.not		procede sul versante bergamasco
ESC_1_146.not		prosegue sulla strada forestale interdetta
ESC_1_160.not		prosegue sulla pista
ESC_1_209.not		prosegue sulla traccia
ESC_1_209.not		prosegue sul fondo del vallone
ESC_1_212.not		continuando sulla traccia
ESC_1_304.not		prosegue sul crinale in piano
ESC_1_329.not		prosegue sui poco inclinati pendii erbosi
ESC_1_396.not		Proseguendo su traccia più deteriorata
ESC_1_445.not		proseguire sulla destra col sentiero
ESC_1_475.not		prosegue sulla pista sterrata fin quasi
ESC_1_497.not		procede sulla pista di servizio

Figure 19: Samples of extraction of lower annotation layers

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