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# Experiments on the Integration of the Danish Language into a Natural Language Text Generation System

## Internal Report

by

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# Chapter 1

## Introduction

As indicated in HERMES [2006], one of the objectives of the HERMES-Project<sup>1</sup> is to communicate observations from an artificial cognitive system to an end-user. Among others, Nagel [2008] describes more precisely how a communication interface could look like and thereby proposes to allow a bidirectional *natural language text* based communication between a user and an artificial cognitive system. The architecture of such an artificial cognitive system is depicted in Figure 1.1.

This report deals with natural language text processing (NLTP), which is handled within the NS of Figure 1.1. In general, NLTP is subdivided into two research fields:

1. Natural Language Text Generation (NLTG) and
2. Natural Language Text Understanding (NLTU).

Information is retrieved from the ‘Interactive Subsystem’ (IS) about what a user might be interested in, i.e. queries entered for NLTU, and it facilitates to output information to the user, e.g. results from NLTG. The ‘Conceptual Subsystem’ (CS) allows inferring knowledge required for both NLTG and answering queries analysed by the NLTU component. One approach for NLTG, called **Angus2**, is described in Gerber [2000] and Fexa [2008]. This approach is an implementation of the NS depicted in Figure 1.1. Larsen et al. [2007] extended the scope of **Angus2** by adding a Danish language implementation.

However, when work started on the HERMES-Project at the IAKS, studies revealed some run-time problems of **Angus2**<sup>2</sup>. In addition, **Angus2** was not designed to deal with the problem of NLTU. The idea to modify **Angus2** to an extent which allows NLTU or to integrate a NLTU-capable module into **Angus2** was pursued by Lang [2007]. The studies revealed that a seamless integration into **Angus2** was likely to be time-consuming and maybe not extendable. Therefore, it was decided to develop a new NLTP system. Despite of its complexity this approach was considered to be preferable to an extension of **Angus2** because of the newly designed capability to use a single language-dependent grammar for both NLTG and NLTU.

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<sup>1</sup>Information about the HERMES-Project can be obtained from <http://www.hermes-project.eu>.

<sup>2</sup>The run-time problems appear to be solved by now, see Nagel & Harland [2008].

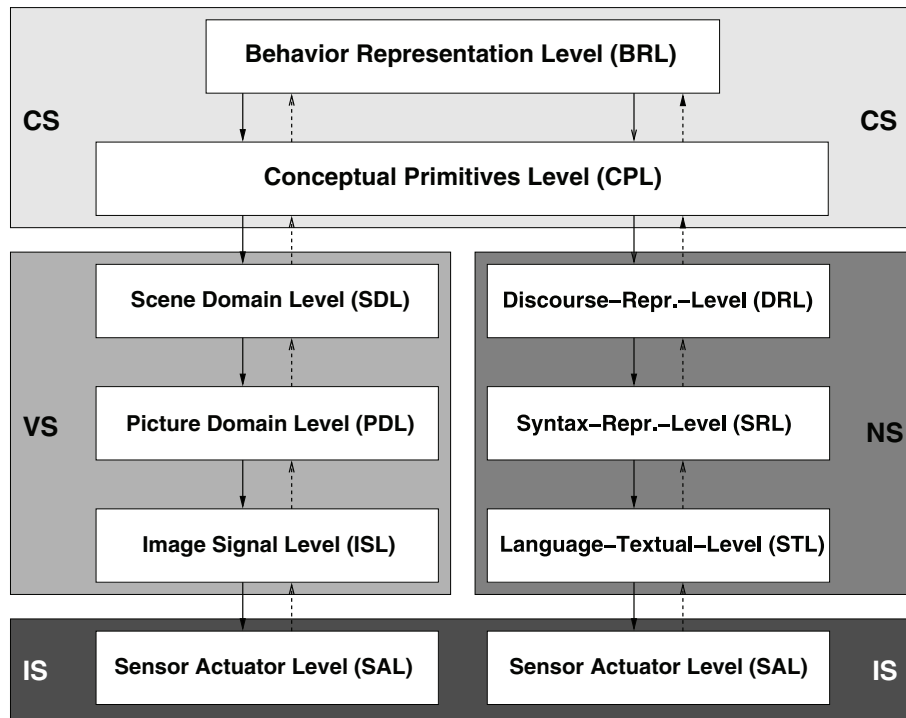


Figure 1.1: The architecture of the newly designed artificial cognitive system is closely related to the one described by Nagel [2004], Gerber [2004] and Arens [2004]. CS stands for ‘Conceptual Subsystem’, VS for ‘Visual Subsystem’, IS for ‘Interactive Subsystem’ and NS stands for ‘Natural Language Subsystem’.

Since the HERMES-Project is an EU-funded project, it was intended from the beginning to create a multi-language NLTP system<sup>3</sup>. In order to generate Danish text using the new approach, a Danish-specific grammar file had to be created. For this reason H. Harland stayed at CVMT from 8th June to 14th June 2009. Since H. Harland has not had any knowledge about the Danish language at the time of the visit, the grammatical knowledge was obtained from Fix-Bonner [2008]. A German specific grammar file<sup>4</sup> had been created prior to H. Harland’s Aalborg visit, and could therefore be used as a guideline. It should be mentioned that the multi-language NLTP system was not intended to be complete, but at least usable to a reasonable extent. In particular, it should reveal potential weaknesses of the newly pursued approach.

<sup>3</sup>see HERMES [2006] Section 6.5, p. 47

<sup>4</sup>also created by H. Harland

# Chapter 2

## Implementation

### 2.1 Implementing the Danish grammar

Following the grammar based approach, the Danish text-generation started by identifying the basic *Parts of Speech* (PoS) of the Danish language. The following parts of speech were selected as a starting point:

- articles,
- nouns,
- adjectives,
- verbs,
- prepositions.

Based upon these PoS, the grammar for sentence building was built subsequently.

#### 2.1.1 Articles and nouns

The Danish language differentiates between two gender-classes:

- neuter (intetkøn), and
- ‘utrum’ (fælleskøn).

The utrum-class will be further differentiated into male and female only when pronouns are used.

As in German, the Danish language has a definite and an indefinite article. Generally spoken the indefinite article is placed as an independent word before the noun. Its syntactical form depends on the gender. The definite article is added as a postfix to the noun, if no adjective

is present, otherwise it is placed before the adjective. Adjectives are placed before a noun. Although there is no exception to the rule when to combine a noun and its article, the syntactical form is partly irregular due to vowel- and stem-changes of the noun.

Syntactically seen<sup>1</sup>, each Danish noun can be assigned to one of six noun-class. The assignment of a noun to one of these classes defines how the plural form of a noun should be formed. Unfortunately, the plural form of a noun does also depend on the intonation of the word. Although first approaches looked promising, the authors have not been able to automatically generate the plural form of nouns since each class contains not yet - by us - fully understood rules about vowel changes.

In order to avoid loosing time figuring out the exact rules for generating the correct syntactical form for each noun, the singular-definite, singular-indefinite, plural-definite, and plural-indefinite form was added to the lexicon. However, depending on the form, each noun is added to a different noun-specific rule set in order to assure that an article is added when required.

### 2.1.2 Verbs

According to Nagel [2008], a list of ‘basic’-verbs has been provided which are supposed to be used when describing a HERMES-scenario. From a syntactical point of view, these verbs can be associated to different classes according to their syntactical requirements. The following classes have been identified:

- intransitive verbs,
- transitive verbs,
- reflexive verbs.

While transitive verbs require an object, intransitive do not (e.g. ‘to cross sth.’ vs. ‘to jog’). Reflexive verbs are special since the required object is referring to the same identity as that of the subject. There is the possibility for all three verb-classes that a verb contains particles (in the following considered as particle-verbs). Particle verbs have to be handled separately, because the position of the particle relative to the verb depends on the verb. Normally, the particle directly follows the verb (e.g. ‘dukker op ...’ = appear). This can be seen as a general rule for intransitive verbs. For transitive verbs, no general rule has been identified yet by us. Some transitive verbs require the object following the particle (e.g. ‘gå ind i ...’ = enter), others require the object between the verb and the particle (e.g. ‘samle ...op’ = pick up). In consequence, seven different classes have been used in order to cope with the position of the particles with respect to the object.

- IntransVerbAction;
- IntransVerbActionParticle;

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<sup>1</sup>according to Fix-Bonner [2008].

- TransVerbAction;
- TransVerbActionParticleI;
- TransVerbActionParticleII;
- ReflexiveVerbAction;
- ReflexiveVerbActionParticle.

Once the the rule-set for each class had been created and the verbs had been assigned appropriately, simple sentences could be created.

### 2.1.3 Structure of a sentence

The most frequent word order within a Danish sentence is ‘Subject - Verb - Object’ (SVO). Normally, declarative sentences are build up according to this rule. The word order normally changes:

- for questions (Question Particle - Verb - Subject) and
- when temporal adverbial phrases are used (Adverbial Phrase - Verb - Subject - Object)

The new NLTP approach used here implements the word order into the verb-classes, since the position of the subject and of objects relative to the verb constrains the meaning of the sentence.

Sentences using spatial preposition phrases can be and have been created as well, since spatial adverbial phrases are placed after the SVO structure.

### 2.1.4 Prepositions

As mentioned above, spatial prepositions are placed after the SVO structure. A list of spatial prepositions has been prepared and translated to Danish<sup>2</sup>. However, making use of spatial prepositions requires that these are explicitly modelled in the Conceptual Subsystem which is not yet done to a full extent.

## 2.2 Problems

Although the currently implemented Danish grammar has to be considered rudimentary, only one problem has been revealed so far. This problem arises when the German language<sup>3</sup> uses compounds instead of a number of nouns (e.g. ‘Blickfeld’ (German) vs. ‘hjørne af billedet’

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<sup>2</sup>see Appendix [A.3](#)

<sup>3</sup>This problem might turn up for any language using compounds.

(Danish)). Since sentence realization depends on the conceptual description, this problem can be solved by providing the most general conceptual description for all languages. As a result the text description would not use compounds, but concretize nouns using other nouns or relative clauses. A disadvantage of this approach is that the resulting text may appear stylistically unfamiliar for those languages where compounds would normally be used (e.g. ‘im Bereich des Bildes’ instead of ‘Bildbereich’).

The latter could possibly be solved by defining language dependent rules about when to combine multiple propositions within the conceptual description into a single one.

## 2.3 Results

Using tracking results by Roth et al. [2008] from ETHZ for the video sequence `CVC_Outdoor_Cam1`, a few sentences have been generated in Danish and listed in Table 2.1. The corresponding German text is listed as well. A snapshot of the scene at time-point 453 is shown in Figure 2.1.



Figure 2.1: This is a snapshot of the video sequence `CVC_Outdoor_Cam1` at the time-point 453. An agent enters the scene in the upper left corner of the image.

Table 2.1: This listing shows sentences generated for the German and Danish language. Words containing an underscore character are fixed labels and are independent from the underlying language.

<b>Time point</b>	<b>sentence</b>
453	: Ein Fußgänger namens Actor_0 erscheint in dem oberen linken Bildbereich von Camera_1.
467	: Er geht auf dem südöstlichen Bürgersteig.
574	: Ein Fußgänger namens Actor_1 erscheint in dem mittleren Bildbereich von Camera_1.
576	: Actor_0 geht auf dem südöstlichen Bürgersteig.
630	: Er bleibt stehen.
453	: En fodgænger navngivet Actor_0 dukker op i det øverst venstre billede fra Camera_1.
467	: Han går på det sydøstlige fortov.
574	: En fodgænger navngivet Actor_1 dukker op i det centrale billede fra Camera_1.
576	: Actor_0 går på det sydøstlige fortov.
630	: Han stopper.
End	

The example above demonstrates that Danish text could be generated from the same input data used for German text generation. Apart from the problem explained in Section 2.2, the generated text is correct. The referring expression generation described in Harland [2008] worked without language dependent modifications. Further testing of the Danish text generation module requires a more detailed conceptual description for a video sequence.

## 2.4 Conclusion

Based on first results for the new NLTP approach<sup>4</sup> in German, this explorative implementation of the Danish language was used to identify errors within the conception of a multi-language NLTP-system extension. Although only one weak point has been revealed so far, the newly implemented approach proved to be suitable for Danish natural language text generation.

<sup>4</sup>see Harland [2008]

In spite of the fact that questions have not been handled explicitly in the newly implemented Danish grammar, first tests showed that the NLTP-system classified Danish declarative sentences entered into the NLTU-query-interface as declarative sentences. No changes had to be made to the NLTP-system whatsoever. This lets hope that an implementation of - simple - questions should be possible within reasonable time. Implementing questions and relative clauses was envisaged, but could not yet be completed due to the limited time available for the visit in Aalborg. Both of the topics have been talked about in Aalborg, but their treatment has been postponed.

Appendix A lists a collection of verbs, nouns, etc. already implemented into the Danish grammar file. The translation work shall enable H. Harland to continue his work on the Danish language at least to an extent that does not require to have a native speaker permanently assisting him. Most of them could not yet be tested, since an appropriate explicit conceptual description is missing at present. However, it should be a matter of time to catch up on creating an adequate description.

## 2.5 Acknowledgement

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<sup>5</sup><http://www.hermes-project.eu>

# Appendix A

## Translation work

This appendix contains a list of nouns, verbs, spatial prepositions, and a test bed. The English data have been prepared in advance at the IAKS by H. Harland. After H. Harland's arrival in Aalborg, M. Andersen translated the English words rapidly into the Danish language allowing quick progress. Although some of the word forms comply with standard Danish inflection rules and therefore do not need to be listed, it is important to a non-native speaker (H. Harland) to verify correctness in grammatical terms. Another advantage of this approach is that context-specific translation issues could be identified by M. Andersen.

### A.1 Nouns

English	Gender	Singular-indefinite	Singular-definite	Plural-indefinite	Plural-definite
arm	utrum	arm	armen	arme	armene
bag	utrum	taske	tasken	tasker	taskerne
bank	utrum	bank	banken	banker	bankerne
body	utrum	krop	kroppen	kroppe	kroppene
box	utrum	boks	boksen	bokse	boksene
bus	utrum	bus	bussen	busser	busserne
bus_stop	neutrum	bus- stoppested	bus- stoppestedet	bus- stoppesteder	bus- stoppestederne
car	utrum	bil	bilen	biler	bilerne
chair	utrum	stol	stolen	stole	stolene
color	utrum	farve	farven	farver	farverne
crosswalk	utrum	fodgænger- overgang	fodgænger- overgangen	fodgænger- overgange	fodgænger- overgangene
curb	utrum	kantsten	kantstenen	kantsten	kantstenene
door	utrum	dør	døren	døre	dørene

**to be continued ...**

- continued -					
Nouns	Gender	Singular- indefinite	Singular- definite	Plural- indefinite	Plural- definite
fence	neutrum	hegn	hegnet	hegn	hegnene
finger	utrum	finger	fingeren	fingre	fingrene
forearm	utrum	underarm	underarmen	underarme	underarmene
hand	utrum	hånd	hånden	hænder	hænderne
head	neutrum	hoved	hovedet	hoveder	hovederne
lamp	utrum	lampe	lampen	lamper	lamperne
lamp_post	utrum	lygtepæl	lygtepælen	lygtepæle	lygtepælene
leg	neutrum	ben	benet	ben	benene
minibus	utrum	minibus	minibussen	minibusser	minibusserne
object	utrum	genstand	genstanden	genstande	genstandene
pedestrian	utrum	fodgænger	fodgængerens	fodgængere	fodgængerene
pedestrian- _crossing	utrum	fodgænger- overgang	fodgænger- overgangen	fodgænger- overgange	fodgænger- overgangene
road	utrum	vej	vejen	veje	vejene
sedan	utrum	sedan	sedanen	sedaner	sedanerne
bus_stop- _shelter	neutrum	skur	skuret	skure	skurene
sidewalk	neutrum	fortov	fortovet	fortove	fortovene
suv	utrum	sportsvogn	skortsvognen	sportsvogne	sportsvognene
stationwagon	utrum	stationcar	stationcaren	stationcars	stationscarene
step	neutrum	trin	trinet	trin	trinene
street	utrum	gade	gaden	gader	gaderne
table	neutrum	bord	bordet	borde	bordene
torso	utrum	overkrop	overkroppen	overkroppe	overkroppene
traffic_light	neutrum	lyskryds	lyskrydset	lyskryds	lyskrydsene
traffic_sign	utrum	færdselstavle	færdselstavlen	færdselstavler	færdselstavlerne
tram	utrum	sporvogn	sporvognen	sporvogne	sporvognene
tram_stop	neutrum	sporvogns- stoppested	sporvogns- stoppestedet	sporvogns- stoppesteder	sporvogns- stoppestederne
tree	neutrum	træ	træet	træer	træerne
truck	utrum	lastbil	lastbilen	lastbiler	lastbilerne
van	utrum	varevogn	varevognen	varevogne	varevognene
vehicle	utrum	varebil	varebilen	varebiler	varebilerne
vehicle	neutrum	køretøj	køretøjet	køretøjer	køretøjerne
waiting_line	utrum	stoplinje	stoplinjen	stoplinjer	stoplinjerne
view_area	neutrum	billede	billedet	billeder	billederne
dog	utrum	hund	hunden	hunde	hundene
ball	utrum	bold	bolden	bolde	boldene

to be continued ...

- continued -					
Nouns	Gender	Singular- indefinite	Singular- definite	Plural- indefinite	Plural- definite
trashbin	utrum	skrældespand	skrældespanden	skrældespande	skrældespandene
leather	neutrum	læder	læderet	n.a.	n.a.
	neutrum	skind	skindet	skind	skindene
boy	utrum	dreng	drengen	dreng	drengene
girl	utrum	pige	pigen	piger	pigerne
man	utrum	mand	manden	mænd	mændene
woman	utrum	kvinde	kvinden	kvinder	kvinderne
lady	utrum	dame	damen	damer	damerne
exit	utrum	udgang	udgangen	udgange	udgangene
room	neutrum	rum	rummet	rum	rummene
End					

## A.2 Verbs

Verb	Verb- Stem	Infinitiv	Present form	Simple-past form	Participle perfect form
jog	jog	jogge	jogger	joggede	jogget
run	løb	løbe	løber	løb	løbet
stand	stå	stå	står	stod	stået
stop	stop	stoppe	stopper	stoppede	stoppet
walk	gå	gå	går	gik	gået
accelerate	accelererer	accelerere	accelererer	accelererede	accelereret
appear	kom til syne	komme til syne	kommer	kom	kommet
appear back up / step-back	duk op træd til- bage	dukke op træde	dukker op træder	dukkede op trådte	dukket op trådt
cross	kryds	krydse	krydser	krydsede	krydset
disappear	forsvind	forsvinde	forsvinder	forsvandt	forsvundet
enter	gå ind i	gå ind i	går ind i	gik ind i	gået ind i
leave	forlad	forlade	forlader	forlod	forladt
move	bevæg	bevæge	bevæger	bevægede	bevæget
move	flyt	flytte	flytter	flyttede	flyttet
to be continued ...					

- continued -					
Verb	Verb-Stem	Infinitiv	Present form	Simple-past form	Participle perfect form
slow down	sæt farten ned	sætte farten ned	sætter farten ned	satte farten ned	sat farten ned
turn	vend	vende	vender	vendte	vendt
wait	vent	vente	venter	ventede	ventet
bow down	buk	bukke	bukker	bukkede	bukket
carry	bær	bære	bærer	bar	båret
chase	jagt	jagte	jagter	jagtede	jagtet
cross					
deposit	sat	sætte	sætter	satte	sat
disappear					
drop	tab	tabe	taber	tabte	tabt
embrace	omfavn	omfavne	omfavner	omfavnede	omfavnet
greet	hils	hils	hilser	hilste	hilst
look / look at	kig	kigge	kigger	kiggede	kigget
take	tag	tage	tager	tog	taget
meet	mød	møde	møder	mødte	mødt
nod	nik	nikke	nikker	nikkede	nikket
pick up	saml op	samle op	samlers op	samlede op	samlet op
point with	peg med	pege med	peger med	pegede med	peget med
raise	løft	løfte	løfter	løftede	løftet
rise from	rejs sig	rejse sig	rejser sig	rejste sig	rejst sig
shake	ryst	ryste	ryster	rystede	rystet
sit on	sid	sidde	sidder	sad	siddet
sit_down(on)	sæt sig ned (på en ...)	sætte	sætter	satte	sat
stand up from					
straighten	ret	rette	retter	rettede	rettet
walk around	gå omkring	gå	går	gik	gået
wave	vinke	vink	vinker	vinkede	vinket
argue	skænde	skændes	skændes	skændtes	skændtes
bark	gø	gø	gør	gøede	gøet
snow	sne	sne	sner	sne	sneet
rain	regn	regne	regner	regnede	regnet
love	elsk	elske	elsker	elskede	elsket
go apart	gå hver til sit	gå	går	gik	gået
End					

## A.3 Spatial prepositions

English	Danish
above	over
across	over
after	efter
against	imod
along	hen ad
among	iblandt
around	rundt om
behind	bagved
below	under
beside	Ved
between	imellem
by	Ved
close to	tæt på
down	ned af
from	fra
in front of	foran
inside	inde i (inside) / indendørs (indoor)
into	ind i
near	I nærheden af
next to	ved siden af
off	ned fra / op fra / væk fra
onto	op på / ned på / hen på
opposite	overfor
out of	ud af
outside	udenfor (without object) / uden for (with object)
over	over
past	forbi
through	igennem
to	til
towards	imod
under	under
up	opad
on	på

End

The list has partly been extracted from <http://www.englisch-hilfen.de> and verified using Fleischhack et al. [2000].

## A.4 Translated test bed

In order to verify syntactical correctness for computer-generated sentences, this test bed has been created. While the semantical representation to these sentences is known, its according Danish text realization was not. Therefore, this - admittedly small - test bed enables a developer to work on Danish text generation and verify its output with these reviewed results.

English	Danish
There is a danger of collision between A and B.	Der er fare for sammenstød imellem A and B.
A pedestrian called Actor_1 appears in the upper left field of view of camera_1.	En fodgænger navngivet Actor_1 dukker op i det øverste venstre hjørne af billedet fra camera_1.
The pedestrian Actor_1 appears in the upper left field of view of camera_1.	Fodgængerens Actor_1 dukker op i det øverste venstre hjørne af billedet fra camera_1.
The pedestrian walks on the sidewalk.	Fodgængerens går på fortovet.
The pedestrian crossed the street.	Fodgængerens krydser gaden.
The pedestrian enters the room.	Fodgængerens går ind i rummet.
The man picks up the bag.	Manden samler tasken op.
The man meets the woman at the trashbin.	Manden møder kvinden ved skrældespannen.
It snows.	Det sner.
I meet the woman which I love.	Jeg møder kvinden som jeg elsker.
I throw the ball which is made out of leather to the boy.	Jeg kaster bolden, som er lavet af læder, til drengen.
He points with his finger to the busstation.	Han peger, med sin fingeren, mod(/imod) busstationen.
The man and the boy argue.	Manden og drengen skændes.
The man argues with the boy on the street.	Manden skændes med drengen på gaden.
The man's car is yellow.	Mandens bil er gul.
The dog of the man barks.	Hunden, der er ejet af manden, gør. / Mandens hund gør.
He goes towards the first exit.	Han går imod den første udgang.
He goes on the Street 'Limmatquai'.	Han går på gaden 'Limmatquai'.
They go apart.	De går hver til sit.
<b>to be continued ...</b>	

- continued -	
English	Danish
They talk to each other.	De taler med hinanden.
They talk together.	De taler sammen.
End	



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