

2019-10-29

# **Explainable Artificial Intelligence and its potential within Industry**



# Talk Outline

1. Background
2. Why Explainable AI?
3. Challenges of using NLG in Industry
4. NLG in trivago
5. Potential areas of NL4XAI in trivago
6. Conclusion

**Background**





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Last Updated: Wednesday, 1 February 2006, 11:55 GMT

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## Experts' baby monitoring project

**Scientists have been carrying out computer research aimed at helping doctors to treat premature babies.**

The £480,000 project - BabyTalk - uses a computer to generate a summary of a baby's medical history and current health status.

The research could aid premature babies

Teams from the University of Aberdeen, the University of Edinburgh, and NHS Lothian have been involved.

If successful, they hope the project could lead to improved medical care throughout the NHS for adults too.

BabyTalk would help doctors and nurses treating premature babies in neonatal intensive care units.

Reports would be produced automatically from the baby's electronic medical notes.

**Reassure families**

**SEE ALSO:**

- Babies 'cost £1,560' before birth  
25 Jan 06 | UK
- Oily fish makes 'babies brainier'  
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**RELATED INTERNET LINKS:**

- University of Aberdeen
- University of Edinburgh
- NHS Lothian
- Engineering and Physical Sciences Research Council

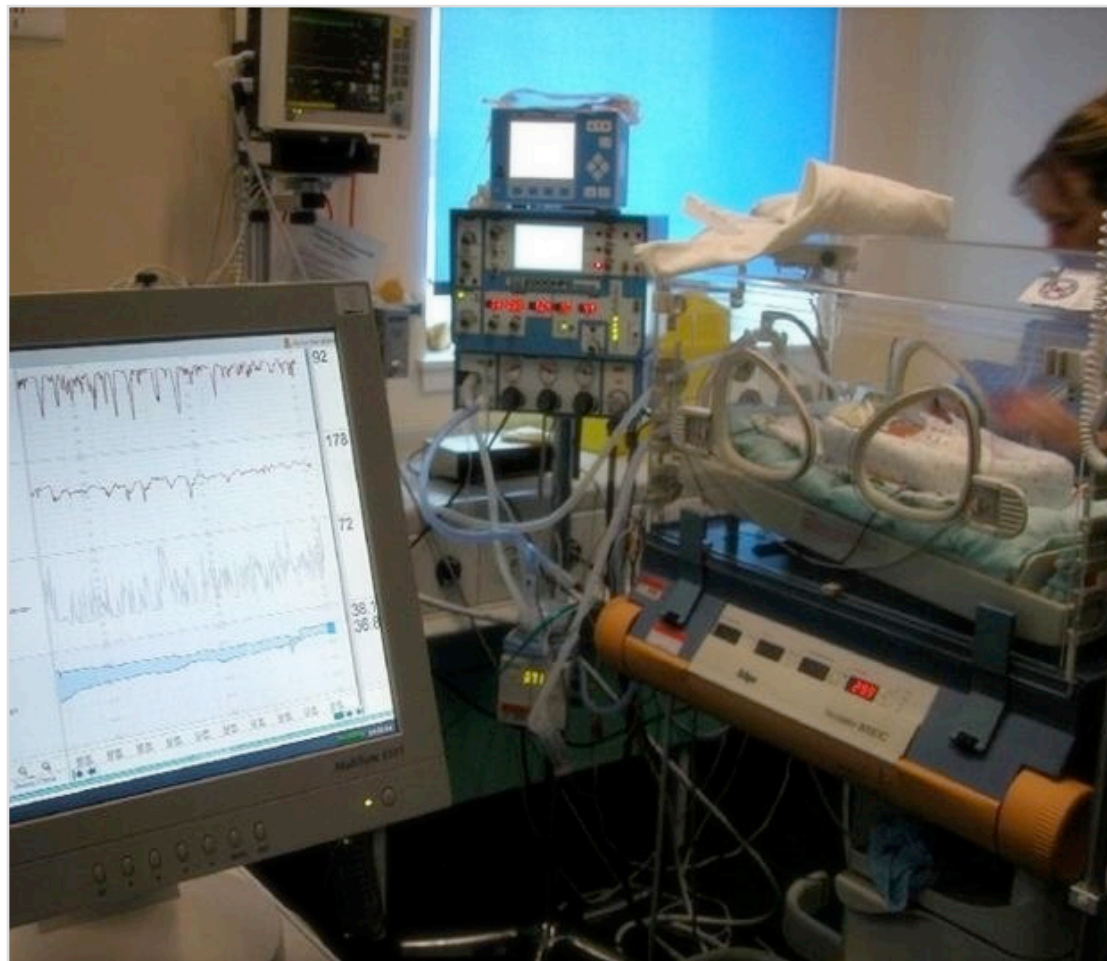
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- Scots unemployment rate increases
- Police name three road crash dead
- Man tried to kill disabled wife

| News feeds







home page patient reports admission discharge patient notes charts Baby Talk reference library help unit reports

100299 : surname, forename

Select cot location...

Single day notes Daily clinical summary Full notes

Selected date

January 2004

Mo Tu We Th Fr Sa Su

5 6 7 8 9 10 11

12 13 14 15 16 17 18

19 20 21 22 23 24 25

26 27 28 29 30 31

Jump to today

Enter ad-hoc event...

Search

- Medical Comment
- Expressing breast milk
- Nursing Comment
- Care plan
- Administration
- Investigation
- Treatments/Procedures
- Other speciality review
- Community
- Spiritual
- Parents
- Social information
- Chart Forms

Wednesday, 7 Jan 2004

Day 7 of life. Corrected gestational age is 24 weeks, 6 Days

Categories filter...

for day Notes/To Do 10:37 - No Valid User

for day Diagnoses/Problems 19:26 - No Valid User

for day Drugs 19:28 - No Valid User

for day Treatments/Procedures 19:30 - No Valid User

00:00 Routine Cultures 31 Mar 04 10:07 - No Valid User

- Specimens sent Other: UVC tip
- Result Coag neg staph

00:15 Surgical procedures 00:13 - No Valid User

- Surgical procedure Laparotomy
- Notes Laparotomy, proximal ileal resection and primary anastomosis. Transverse muscle cutting incision. 3 cm length of ischaemic bowel in proximal ileum with perforation. Remaining small and large bowel normal. Resection of 4 cm of ileum with primary anastomosis with S-O vicryl serosubmucosal int. Mass closure with 3-0 vicryl and S-O Biosyn to skin. Post op Treat as NEC with nil enteral and antibiotics for 10 to 14 days. D\_S1046 Consultant Surgeon

00:45 ysi 02:45 - No Valid User

- YSI - Glucose 15.60 mmol/L

01:50 Medical comment 01:55 - No Valid User

- Topic other - general comment
- Comment returned from LOCATION at 01:45. uncomplicated transfer back HR 135, satz 95% ongoing intubation and ventilation P 24/5, rate 44, FiO2 27%, MAP 32 - ongoing IVI : dextrose/saline; insulin; morphine (20mcg/kg/hr); hepsal -last vecuronium dose at midnight -also had fentanyl in theatre -had 4cm of small bowel resected as per PERSONnote with end-end anastomosis -had 2x 10ml/kg HAS at RHSC plus 15ml/kg platelets but no blood given (Hb 9 on gas machine at RHSC) PLAN:stabilise on vent, check gas and bloods early
- Author D\_S1025 D\_348

02:26 Blood Gas Result 02:33 - Automated source

- pH 7.20
- PCO<sub>2</sub> 6.81 kPa
- PO<sub>2</sub> 6.07 kPa
- BE -7.8 mmol/L
- Haemoglobin 10.1 g/L
- Methaemoglobin 1.00
- Sodium 136 mmol/L
- Potassium 2.9 mmol/L
- Glucose 12.70 mmol/L
- Lactate 2.90 mmol/L
- Calcium 1.32 mmol/L
- Bilirubin 88 micromols/L

02:26 Blood gas ventilation 05:20 - No Valid User

- Time of event in notes Date 7 Jan 04 at Time 02:26
- Respiratory support CMV
- Inspired O2 33.00
- Peak airway pressure 22
- PEEP/CPAP 6.0

sysadmin

click here to log out

18:24:49

# BabyTalk Project

Four main BabyTalk Projects, which ran between 2006 to 2012:

- BT-45 (Gatt et al., 2009)
- BT-Nurse (Hunter et al., 2012)
- BT-Family (Mahamood & Reiter, 2011)
- BT-Clan (Moncur et al., 2013)



home page patient reports admission discharge patient notes charts Baby Talk reference library help unit reports Select cot location...

100299 : surname, forename

## BabyTalk-Family Generated Report



**Report Code: BT-136**

**Baby:** 100299

**From** Tuesday, 6<sup>th</sup> of January 2004 **to** Wednesday, 7<sup>th</sup> of January 2004

Your baby, John, is receiving intensive care at the Royal Infirmary of Edinburgh. He is currently being looked after in Blackford nursery in cot space twelve.

John is now 6 days old with a corrected gestation of 24 weeks and 6 days.

Your baby is currently being treated for the following conditions:  
Thrombocytopaenia, Hypotension, Suspected Bacterial Sepsis, Prematurity 24 27 Weeks, Extremely Low Birth Weight, Hyperglycaemia, Intestinal Perforation Postnatal, Proven Necrotizing Enterocolitis, and Respiratory Distress Syndrome.

His last recorded weight was 755 grams (1 lb 11 oz). Because John was born earlier than expected, he has been nursed in an incubator. This keeps him warm by keeping the heat and humidity in the incubator and preventing him from losing too much moisture from his fine skin.

John is currently receiving ventilation support. Ventilation helps to provide the support that enables him to breathe more easily. In the morning, the amount of oxygen required for your baby was 23 %. Ventilation tubes are being used to ensure that the oxygen-enriched air directly reaches your baby's lungs. This ensures that your child's lung airways remains open for oxygenation. There had been acute episodes of apnoea and bradycardia. These episodes were treated by an application of neopuff to assist your baby's breathing.

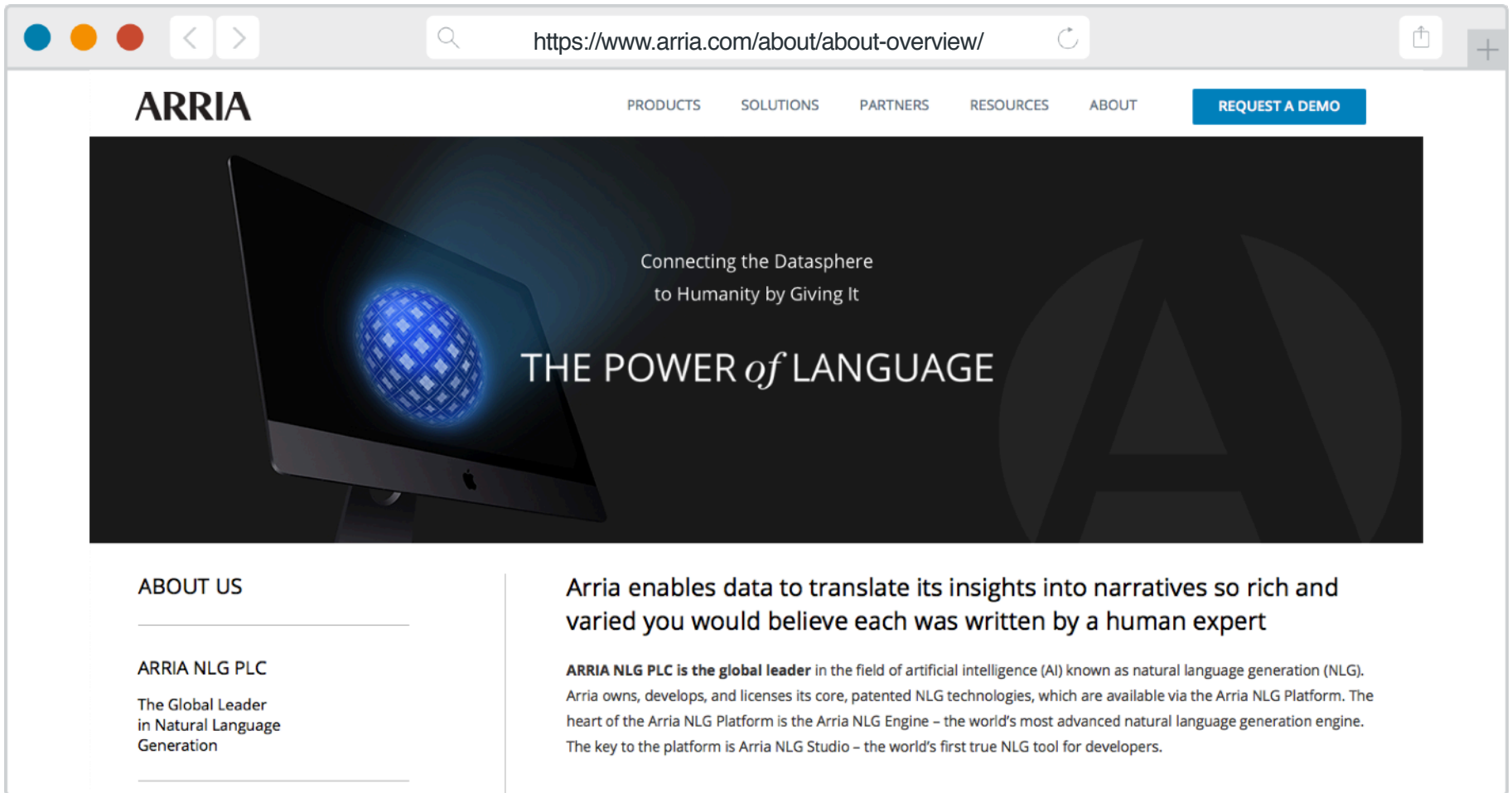
He had a peripheral venous line inserted. He had a venous line removed. Over the last day, your baby received the following types of fluid and feeds: TPN and glucose. We are giving John some glucose through the tube that goes into his vein. He is fed on a glucose solution at 4.2 mls. Additionally, John is currently receiving total parental nutrition (TPN) to meet his nutritional needs. At present, milk feeds have remained stable over the last 24 hours at around 0.7 mls. John is making positive progress with his milk feeds and we anticipate continuing improvements. Overnight, his blood sugars were 12.7 - 15.8 mmol/L.

badger sysadmin click here to log out... 22:29:45

# BT-Family Findings

The main findings from the BT-Family research project:

- How information is communicated matters. BT-Family took account of the information that needed to be summarised and used communicative strategies to deal with information that may induce stress for a given parent.
  - When evaluated 80% of parents preferred texts that account of such communicative strategies.
- When the reports were evaluated on-ward 70% of parents ( $n=38$ ) felt that information contained within the reports that were either “Very Good” or “Excellent”.
- The reports also enabled parents in 81% of respondents to explain their baby's treatments to other family members/relatives/friends either to “some extent” or “completely”.



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ABOUT US

ARRIA NLG PLC

The Global Leader in Natural Language Generation

Overview

Our Vision

Our Mission

Our Mantra

The Datasphere

Arria NLG Everywhere

Our Scientific Foundation

Our Foundational Patents

The Advent and Impact of NLG

The Power of Language

Arria enables data to translate its insights into narratives so rich and varied you would believe each was written by a human expert

ARRIA NLG PLC is the **global leader** in the field of artificial intelligence (AI) known as natural language generation (NLG). Arria owns, develops, and licenses its core, patented NLG technologies, which are available via the Arria NLG Platform. The heart of the Arria NLG Platform is the Arria NLG Engine – the world’s most advanced natural language generation engine. The key to the platform is Arria NLG Studio – the world’s first true NLG tool for developers.

THE ARRIA NLG ENGINE

RAW DATA

DATA ANALYSIS

FACTS

DATA INTERPRETATION

MESSAGES

DOCUMENT ORCHESTRATION

DOCUMENT PLAN

MICRO PLANNING

SENTENCE PLAN

SURFACE REALIZATION

SURFACE TEXT

At the Heart of the Most Advanced Natural Language Generation Platform

trivago

13

# Arria NLG

In addition to working on core IP also built applied NLG projects in multiple commercial domains ranging across:

- Finance
- Travel
- Agriculture
- Healthcare
- etc.



# Multimodality & NLG

## Monthly Report for October, 2011

This month the market was positive with FTSE gaining 9.23 percent. Your portfolio rose by 22.84 per cent to 176777.5 GBP. Your simple return stands at 16.736 per cent.

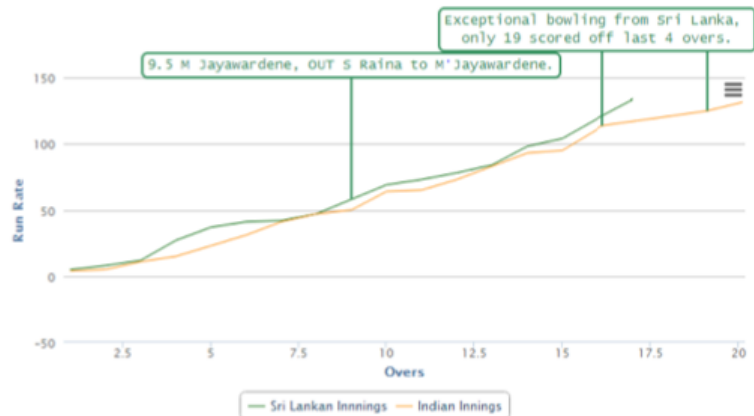
Looking at your holdings, Mining stocks rose the most with a 0.42 percent advance. During this period Antofagasta advanced 26.71 per cent. London Stock Exchange Group enjoyed a gain over the last 5 days. Overall eight of your stocks rose and one fell. Your exposure to the Mining sector stands at 52.5 making your portfolio highly skewed. With recent purchase of Barclays shares your exposure to the Banking sector grew to 15.80 per cent. The most volatile security during this month was BAE Systems.

### SUMMARY

Current Value 1.76777455E7 Simple Return 16.736%

Security Name	Last Price (GBP)	Quantity	Today's % Value Change	Current Value
Aberdeen Asset Management	174.77	200	0.113%	349.54
Antofagasta	1137.6	5200	0.267%	59153.2
BAE Systems	2.77	5350	0.069%	148.2
Barclays	185.09	7350	0.25%	13604.12
BHP Billiton	1770.23	15350	0.151%	271730.3
HSBC Holdings	490.36	16350	0.118%	80173.86
Lloyds Banking Group	32.49	17550	-0.029%	5702
London Stock Exchange Group	847.31	17570	0.107%	148872.37
Sage Group	283.0	17670	0.082%	50006.1

## Portfolio Value vs FTSE100





trivago













# Über trivago

- Founded in 2005 by three University friends in Düsseldorf.
- Focused on helping users to find the ideal accommodation and the right price.
- Conducts business in 190 countries with over 3+ million hotels and accommodations.
- Over 1200+ employees.
- Based in four locations:
  - Düsseldorf — Company headquarters
  - Leipzig
  - Amsterdam
  - Palma de Mallorca

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# trivago Hotel Profiling

Hotel Profiling helps to derive the unique characteristics of accommodations from factual data to enable travellers to choose the ideal hotel. We work on the following areas:

- **Perceived Quality** — How good is a Hotel X compared to Y?
- **Price Knowledge** — Is €120 per night on Jan 22 a good price for Hotel X?
- **Location Knowledge** — Is Hotel X in Amsterdam? If I want to visit Rijksmuseum, what are the best hotels around?
- **Image Knowledge** — Which images do we show to users as gallery images and main images? What images are most relevant to users who want romantic hotels?
- **Review Knowledge** — Which reviews are the best to show to users? Which review gives the most information about the swimming pool?

# Why Explainable AI?

# Why do we need Explainable AI?

- Increasing adoption of ML/AI models within industry and academia.



BANK OF ENGLAND



# Machine learning in UK financial services

October 2019





Chart 1 Two thirds of respondents have live machine learning applications in use

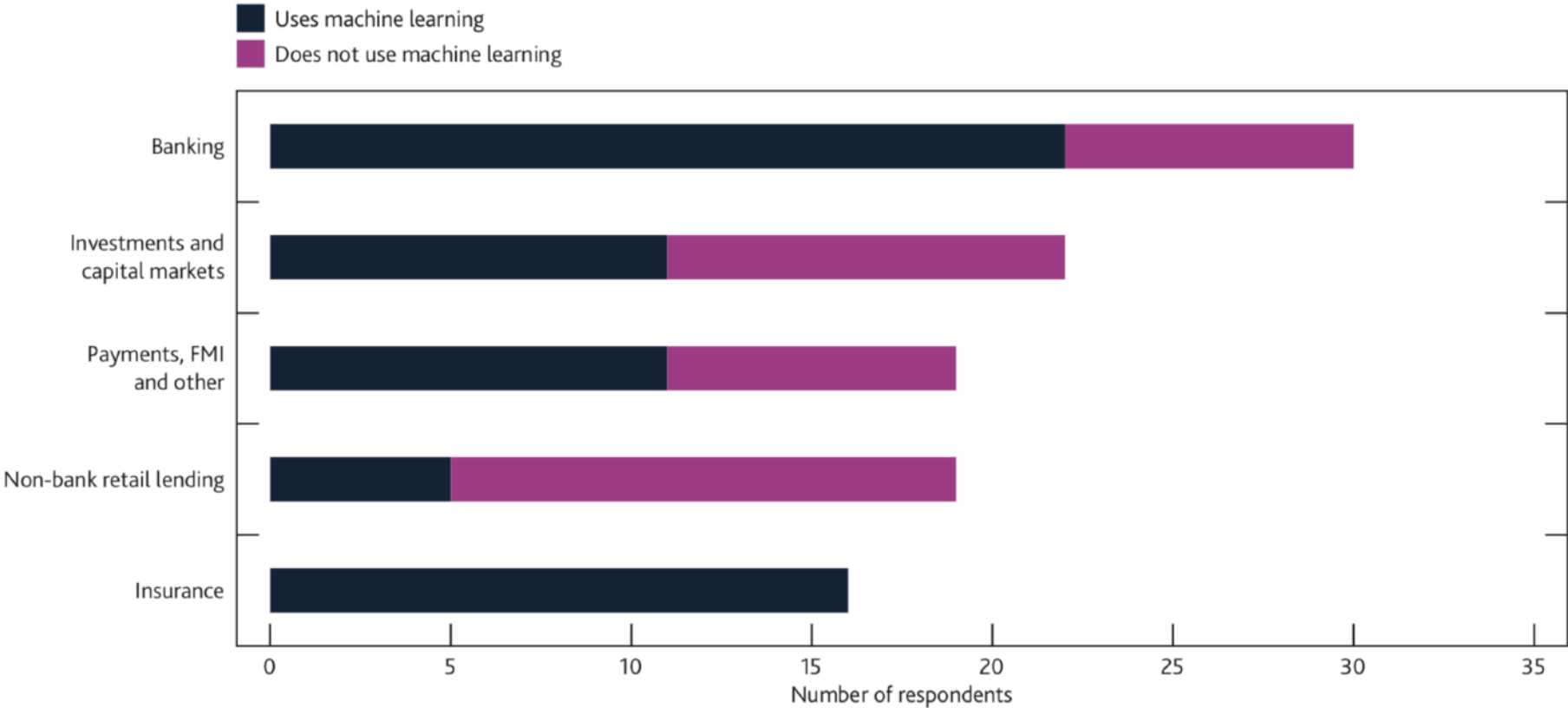
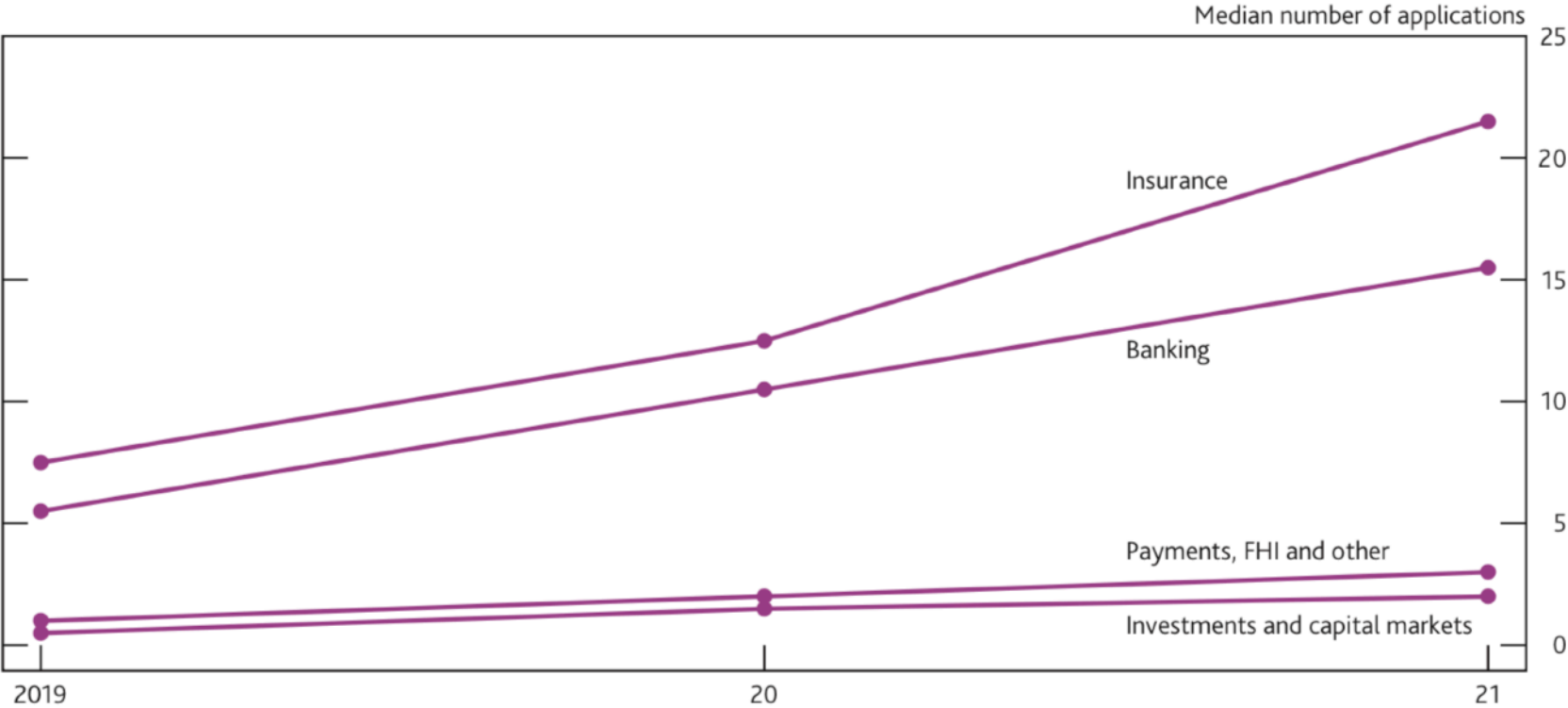


Chart 2 Respondents expect significant growth in use of machine learning over the next three years



# Why do we need Explainable AI?

- Increasing adoption of ML/AI models within industry and academia.
- However, a lot of these models ML/AI models are opaque, non-intuitive, and difficult for people to understand.
  - Increasing legislative steps such as "Right to explanation" as part of the recently enacted European Union's General Data Protection Regulation
- By providing explanations it will enable ML/AI models that allow users to understand, trust, and verify.

# Potential Benefits of Explainable AI

There are some potential benefits to having having explainable AI solutions (Samek et al., 2017):

- **System Verification** — Does the system perform/behave the way it should? Especially important for some domains such as Healthcare.
- **System Improvement** — By enabling transparency through explanations it is possible to find weaknesses and areas of underperformance.
- **Learning from the System** — Allow for the distillation of patterns learned by a model to be better understood by humans.
- **Compliance with Legislation** — Does the system discriminate or introduce bias? Is it in legal compliance?

Examples:

- [Washington Post: Racial bias in a medical algorithm favors white patients over sicker black patients](#) (October 24. 2019).
- [ProPublica: Biased ML facial recognition models that predict crime recidivism rates](#) (May, 2016).

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# Explanation Modalities

There are four potential modalities for the display of explanations of AI models (Gunning, 2017):

- **Analytic Statements** — Natural language statements that describe the elements and the context that supports the choices made.
- **Cases** — Invocation of specific examples or stories that supports the choices made.
- **Visualisations** — Graphics that directly highlight portions of raw data that supports a choice and allows users to form their own understanding.
- **Rejection of alternative choices** — Statements that argue against alternative choices using answers based on analytics, cases, and data.

For at least of three out of theses modalities there is a strong potential to use NLG to generate explanations!

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# Challenges of using NLG in Industry

# Commercial NLG Systems

- Rich history of building commercial NLG systems — e.g. FoG (Goldberg et al., 1994).
- Commercial systems are present in various domains such as:
  - Weather (Sripada et al., 2014)
  - Automated Journalism (Caswell and Dörr, 2018)
  - Oil & Gas (Reiter, 2017)
  - Healthcare (Harris, 2008)
  - Financial Reporting (Danlos et al., 2011).
- Substantial increase in the number of commercial NLG solutions in the last 5-10 years (Dale, 2019).



# Corpus Analysis Challenges

- Before even building a given commercial NLG system analysing the corpora can induce the following challenges:
  - Unavailability of corpora (Sripada et al., 2014).
  - Lack of consistency of style in corpora due to multiple authors (Sripada et al., 2004)
  - Lack of data access due to privacy (Harris, 2008).

# Building Commercial NLG System Challenges

- Commercial NLG systems differ substantially from academic systems in several key aspects:
  - **Lower levels of technical capability** — lower use of rich linguistic concepts such as REG, aggregation, etc (Dale, 2019).
  - **Greater focus on ensuring the reliability/accuracy** — To avoid legal or commercial liabilities (Harris, 2008).
  - **Reusability & Configurability** (Sripada et al., 2014; Reiter 2017).
  - **Absence of appropriate of Data** (Caswell and Dörr, 2018).
  - **Scalability for large output generation** (Harris, 2008).
- Because of the challenges there is sometimes a focus on simplicity instead of cutting-edge techniques (Harris, 2008).

**NLG in trivago**

**Enter Hotel or  
Destination**

Paris

Search

**Filter**



**Find Your  
Ideal Hotel**



**Compare Hotel Types,  
Prices and Extras**



**Book**



**Forward to Online  
Travel Agency,  
Independent Hotel  
or Hotel Chain**

# NLG & trivago Accommodation Descriptions

# Problem Description

- Texts for accommodation descriptions were generated using a team of freelancers for each language or through the hotelier. However, the long tail of accommodations may not have any accommodation descriptions and may affect their SEO performance.
- Using NLG can help with several aspects:
  - **Cost** — e.g. English costs on average 0,06 €, per word.
  - **Coverage** — Making sure all accommodations have a description
  - **Update Frequency** — Update details about an accommodation when data changes.
  - **Consistency** — Making sure all accommodations regardless of value have a high quality description baseline.

# Corpus Analysis

- Performed a corpus analysis on human written accommodation descriptions to reverse engineer text back to data where possible and to identify any potential issues.
- General Findings:
  - Lack of specific descriptive details in identity data.
    - For example *"comprehensive breakfast buffet each morning"*.
  - Incomplete coverage of room features in identity data — e.g. Whether there is free in-room bottled water.
  - Paucity of restaurant/dining data — No specific details about type of food service or cuisine type available as an example.
  - POI data challenges — No comprehensive transportation data, inability to generate accurate distances for POIs, unable to suggest relevant nearby POIs for travel types, etc.
- Focused on generating objective descriptions of accommodations as a first starting point.

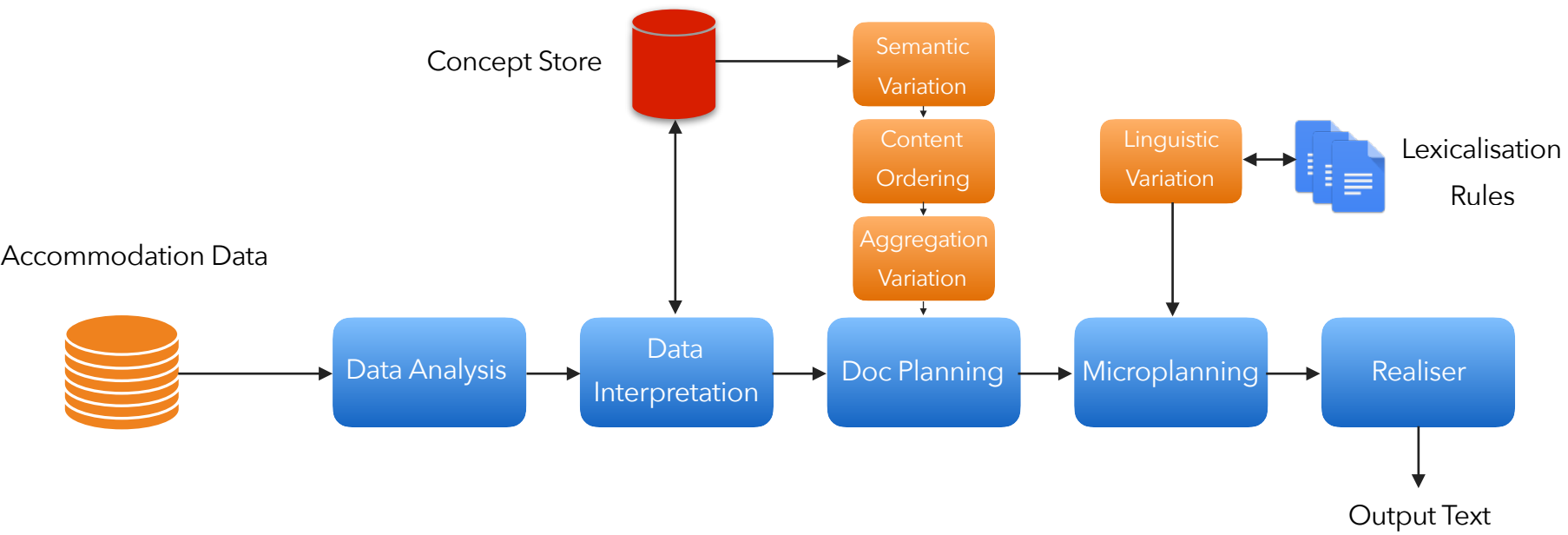
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# Solution: Hotel Scribe

- Hotel Scribe is English only NLG system that can generate accommodation descriptions automatically for Hotels.
- Built with the focus of generating texts with a high level of textual variation for the benefit of SEO. This is done by:
  - **Semantic variation** — Varying what content to talk about.
  - **Content ordering variation** — Varying the order of how content is placed.
  - **Aggregation variation** — Varying how and when concepts should be aggregated in a single sentence or not.
  - **Linguistic variation** — Variation in how the concepts are expressed in language.
    - Phrase/word level variation.
    - REG variation — “accommodation” vs. “hotel” vs. “Hilton”

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# Example Text Output

"The Park Plaza Victoria London, a four-star residence, is a Hotel in London, the United Kingdom. This accommodation is placed near to Victoria Station, making it useful for travellers.

There is no fee Internet connectivity throughout the hotel in both public and in-room hotel areas. Parents of children should note that there are a variety of child friendly facilities including childcare facilities and baby cribs. Visitors can be entertained by the presence of a pool. Parking amenities comprises of a close by car park, with valet parking. Speedy check-in/check-out with a 24 hour front desk is also conveniently available for travellers. For business travellers, this accommodation features conference/meeting rooms and a business centre. Food is obtainable through the provision of an on-site restaurant and a café.

In the Park Plaza room amenities vary and contain an array of features including coffee/espresso machine, ironing board, windows that open and central heating. Entertainment is available for guests, which is provided by pay TV. Additionally, some rooms come with views of the city."

# Example Text Output II — Variation

"The Park Plaza Victoria London, a four-star residence, is a Hotel in London, the United Kingdom. This accommodation is positioned conveniently close to Victoria Station, making it easier for travellers to move about within the city.

This accommodation features a business centre and conference/meeting rooms. There is complimentary Internet access in the hotel in both in-room and public hotel areas. Meal choices are accessible in this accommodation through an in-house restaurant and a café. Parents of children should note that there are several child friendly amenities including childcare facilities and baby cribs. Parking amenities consists of a close by car park, with valet parking. Speedy check-in/check-out can be done at the 24 hour reception from 14:00 for check-ins and as late as 12:00 for check-out. Additionally, guests can be entertained by the presence of a pool in this hotel.

In this hotel, rooms contain amenities such as air conditioning, radio, windows that open and an electric kettle. Visitors have access to cable TV for in-room media entertainment. Additionally, some rooms come with views of the city."

# Evaluation & Current Status

- Evaluated level of textual variation against human and a commercial competitor. Using a commercial **anti-plagiarism software** (copyscape) and **Levenshtein Edit Distance** (Foster & White, 2007).
  - Human texts outperform on both measures Hotel Scribe and the commercial competitor by significant margin.
  - However, Hotel Scribe (44.02, 296.25) has near comparable performance to the commercial competitor (32.43, 345.35).
- In production for generating descriptions of Hotels in English since January, 2019.
- Generated over 600,000 accommodation descriptions.
- Currently, undergoing A/B SEO testing to determine the value of NLG texts.

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Information | [Reviews](#)

### About Traube am See



The Traube am See, a four-star residence, is a [Hotel in Friedrichshafen, Germany](#).

Water related facilities include a whirlpool and an indoor swimming pool. Parents of children should note that there are a few child friendly facilities including a children's playground and baby cribs. Check-in/check-out can be done at the front desk from 14:00 for check-ins and as late as 11:00 for check-out. Food is available through the provision of an on-site restaurant. Parking amenities comprises of a close by car park.

Room features at this accommodation contain a desk, telephone, hairdryer and sound proof windows. Visitors have access to cable TV for in-room media entertainment. Furthermore, some rooms come with views of the lake.

### Contact

Meersburger Straße 11, 88048, Friedrichshafen, Germany

Telephone: +49(7541)9580 | Fax: +49(7541)958888 | [Official Homepage](#)

### Top amenities



**Free** WiFi in lobby



**Free** WiFi in rooms



Pool



Spa



Parking



Pets



A/C



Restaurant



Hotel bar



Gym

## Hotel Scribe: Generating High Variation Hotel Descriptions

Saad Mahamood  
trivago N.V.  
Düsseldorf, Germany  
saad.mahamood@trivago.com

Maciej Zembrzusi  
trivago N.V.  
Düsseldorf, Germany  
maciej.zembrzusi@trivago.com

### Abstract

This paper describes the implementation of the Hotel Scribe system. A commercial Natural Language Generation (NLG) system which generates descriptions of hotels from accommodation metadata with a high level of content and linguistic variation in English. It has been deployed live by *trivago* for the purpose of improving coverage of accommodation descriptions and for Search Engine Optimisation (SEO). In this paper, we describe the motivation for building this system, the challenges faced when dealing with limited metadata, and the implementation used to generate the highly varied accommodation descriptions. Additionally, we evaluate the uniqueness of the texts generated by our system against comparable human written accommodation description texts.

### 1 Introduction

The hotel search business is a highly competitive market in which websites attempt to align the accommodation needs of a given user with the available marketplace of prices/deals offered by hoteliers and other accommodation providers. It is imperative that users are able to find the type of accommodation they are seeking and find relevant information associated to a given accommodation in the form of images, text, maps, and infographics.

One key piece of textual information is an *accommodation description*, which provides a given user with detailed information about the accommodation and the facilities that it offers for their guests. Within *trivago* these descriptions have been typically written manually by humans either with the use of freelancers or the hotelier providing a description themselves. As the global market size of hotels has continuously grown over the past few years this has meant an ever increasing

inventory of accommodations requiring a description. Other problems such as the cost of employing freelancers across multiple languages, the lack of consistency, and the time-lag in providing updated descriptions for accommodations meant that an automated solution for generating accommodation descriptions was needed. Finally, with the importance of SEO for consumers searching for a specific accommodation from a search engine, there was also a need to generate accommodation descriptions with a high level of content and linguistic variation to make generated description as distinct as possible.

In this paper, we will describe relevant past work that has been done using NLG for commercial applications and the use of variation in NLG. In later sections we will describe our approach for generating accommodation descriptions with variation, our methodology for evaluating the effectiveness of the implemented system, and discuss the results that we have obtained. In the final section we conclude the paper based upon the findings we have obtained.

### 2 Background

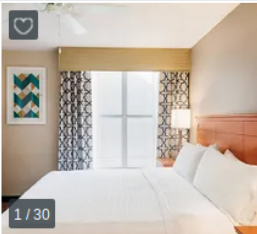
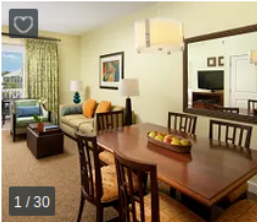
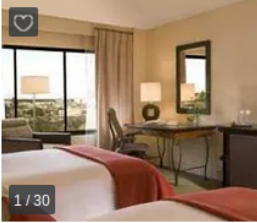
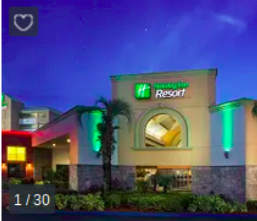
#### 2.1 Commercial NLG

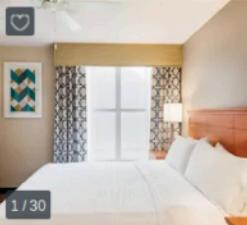
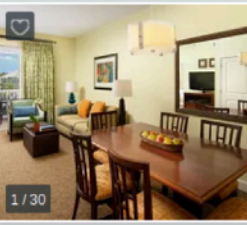
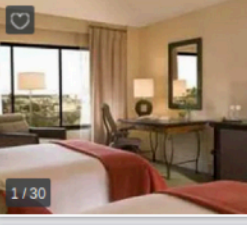
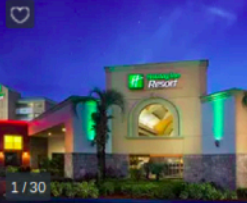
Over the past 5-10 years there has been a substantial increase in the number of commercial based NLG solutions (Dale, 2019). Commercial NLG applications have appeared in differing domains such as Weather (Sripada et al., 2014), Automated Journalism (Caswell and Dör, 2018), Oil & Gas Industry (Reiter, 2017), Healthcare (Harris, 2008), and Financial reporting (Danlos et al., 2011). This increase has been in part due to the rise of companies such as *Narrative Science*, *Automated Insights*, *Arria NLG*, *Yesop*, and *As Semantics*. Whilst there has been some interest among these companies in exploring aspects of

12<sup>th</sup> International Natural Language Generation  
(INLG) Conference, 29<sup>th</sup> of October-1<sup>st</sup> of November, Tokyo, Japan.  
<https://www.inlg2019.com>



# NLG and USP Summaries

	<h3>Homewood Suites by Hilton Orlando The...</h3> <p>Hotel</p> <p>Orlando, 2.9 km to Hilton Grand Vacations at Tuscany Village</p> <p><b>9.1 Excellent</b> (490 reviews)  <u>Extremely clean · Extremely comfortable</u></p>	<p>Homewood Suites €213</p> <p>Expedia €201</p> <p>Hotels.com €201</p> <p>More deals from €201</p>	<p>Homewood Suites <b>€213</b></p> <p>Free breakfast</p> <p><b>View Deal</b></p>
	<h3>Sheraton Vistana Villages Resort Villas, I...</h3> <p>★★★★ Resort</p> <p>Orlando, 1.1 km to Hilton Grand Vacations at Tuscany Village</p> <p><b>9.0 Excellent</b> (15061 reviews)  <u>Excellent location · Extremely comfortable</u></p>	<p>Booking.com €133</p> <p>Expedia €133</p> <p>ebookers.ie €133</p> <p>More deals from €133</p>	<p>Hotels.com <b>€133</b></p> <p>Pay at the hotel</p> <p><b>View Deal</b></p>
	<h3>Hilton Orlando Lake Buena Vista - Disney...</h3> <p>★★★★★ Hotel</p> <p>Lake Buena Vista, 2.6 km to Hilton Grand Vacations at Tuscany Village</p> <p><b>8.2 Very good</b> (11043 reviews)  <u>Excellent location · Very clean</u></p>	<p>Hilton €287</p> <p>Hotels.com €251</p> <p>Expedia €251</p> <p>More deals from €124</p>	<p>Hilton <b>€287</b></p> <p><b>View Deal</b></p>
	<h3>Holiday Inn Resort Orlando Lake Buena V...</h3> <p>★★★★ Resort</p> <p>Lake Buena Vista, 2.0 km to Hilton Grand Vacations at Tuscany Village</p> <p><b>8.2 Very good</b> (4510 reviews)  <u>Excellent location · Extremely clean</u></p>	<p>Hotels.com €135</p> <p>Booking.com €135</p> <p>ebookers.ie €135</p> <p>More deals from €135</p>	<p>Expedia <b>€135</b></p> <p><b>View Deal</b></p>

	<h3>Homewood Suites by Hilton Orlando The...</h3> <p>Hotel</p> <p>Orlando, 2.9 km to Hilton Grand Vacations at Tuscany Village</p> <p><b>9.1</b> Excellent (490 reviews)</p>	<p>Homewood Suites <b>€213</b></p> <p>Expedia €201</p> <p>Hotels.com €201</p> <p>More deals from €201</p>	<p>Homewood Suites <b>€213</b></p> <p>Free breakfast</p> <p><b>View Deal</b></p>
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# Challenges in reviews summarisation

## Target summary: A 1932 Art Deco hotel near cultural hotspots

OLD 11

Art Deco 7

Culture 3

100s

The Great American [redacted] can all be reached within a ten - minute walk of the property.  
It's a charming [redacted] hotel, but after all it is San Francisco.  
It looked like to be remodeled to a hotel from another building.  
- extremely [redacted] and run - down hotel .  
The hotel is of stone and wood and soft-colored rooms and clean well - lighted bathrooms whose design from floor tiles to plumbing obviously have seen history in the past twenty years or so.  
The hotel's extremely [redacted] and not in a very pleasant neighborhood of San Francisco  
For a short stay, the Embassy hotel offers a relaxed peek of the urban and quaint in San Francisco .  
The hotel is an [redacted] building, but appears well maintained and clean.  
Deco charm with mezzanine lounge and adjacent cafe with great freshmade sandwiches .  
it is a classic small hotel.  
The building was charming, clean, and comfortable.  
The hotel was [redacted] and chic.  
The hotel was convenient to everywhere places.  
The room was beautiful a [redacted] and staff were nice.  
Outstanding "Over Look Hotel" sty [redacted]  
The hotel falls downtown, you can smell drugs everywhere around the hotel.  
the hotel is [redacted] and dirty.  
pics look great from internet but the real hotel is not clean and in bad neighborhood.  
Best thing about this hotel was its location, but other than that I have nothing nice to say.  
It's close to the [redacted] town, Union Square and to the Piers.  
The hotel was [redacted] outdated and the bathroom was small.  
Comfortable bed and nice furnishings, but the hotel is very o [redacted] and shabby.text  
Click to add This hotel is a nice o [redacted] building.  
An [redacted] style hotel - this is unique!  
Housed within a striking [redacted] building which dates back to 1932, The Embassy Hotel is an elegant option with a central position in San Francisco.  
Great historic art deco hotel, the rooms were a little musty and could be freshend up, but is to be expected due to the age of hotel.  
The hotel is truly [redacted] in design and furnishings, very interesting.  
The [redacted] architecture and very friendly staff .  
The hotel has an interesting history and was very clean too.  
Great sights nearby: [redacted] restaurants, etc.  
This hotel is right near the tenderloin section of San Francisco.  
HOTEL IS AN ARCHITECTUAL BEAUTY - BUT DOESN'T LOOK LIKE IT'S BEEN REMODELED IN 25+ YEARS.  
This hotel is located in one of the unsafest neighborhoods in San Francisco.  
[redacted] building but refurbished room .

# General Approach

## Reviews

The Great American Music Hall, San Francisco City Hall, and Asian Art Museum can all be reached.  
It's a charming old hotel, but after all it is San Francisco.  
It looked like to be remodeled to a hotel from another building.  
- extremely old and run - down hotel .  
The hotel is of stone and wood and soft -colored rooms and clean well - lighted bathrooms whose design .  
The hotel's extremely dated and not in a very pleasant neighborhood of San Francisco .  
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Best thing about this hotel was its location, but other than that I have nothing nice to say.  
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This hotel is located in one of the unsafest neighborhoods in San Francisco.  
Old building but refurbished room .  
An art deco style hotel - this is unique!

## EXTRACTIVE

1. This hotel is a nice old art - deco building.
2. An art deco style hotel - this is unique!
3. Housed within a striking Art Deco building which dates back to 1932, the Embassy Hotel is an elegant option with a central position in San Francisco.

## ABSTRACTIVE

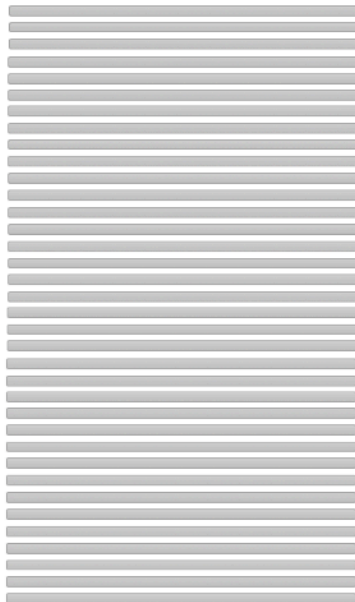
**A 1932 Art Deco hotel near cultural hotspots**

# The extractive approach

## Reviews

The Great American Music Hall, San Francisco City Hall, and Asian Art Museum can all be reached.  
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Old building but refurbished room .  
An art deco style hotel - this is unique!

## Universal Sentence Encoder vectors



## Target vector

**A 1932 Art Deco  
hotel near cultural  
hotspots**



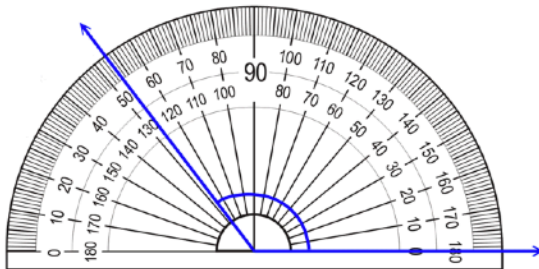
# Finding Abstractive Candidate Sentences

sentence

sentence

sentence

sentence



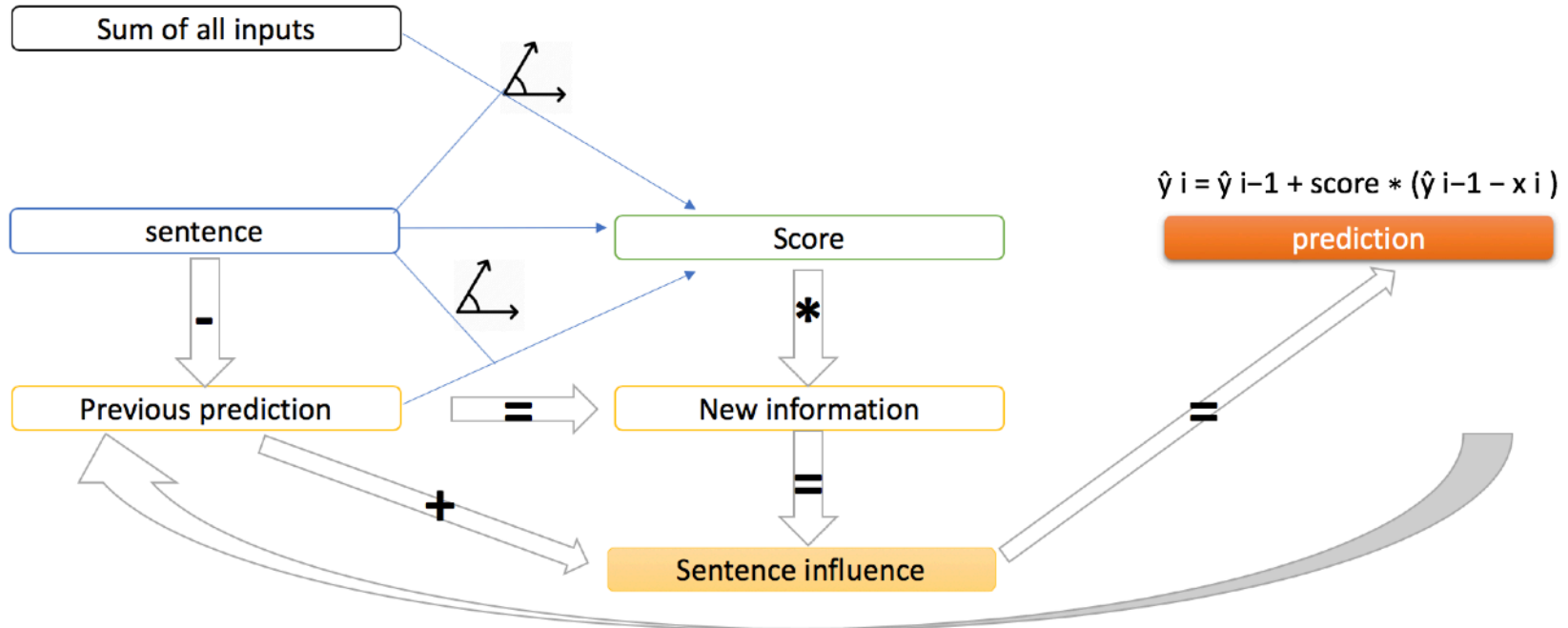
prediction

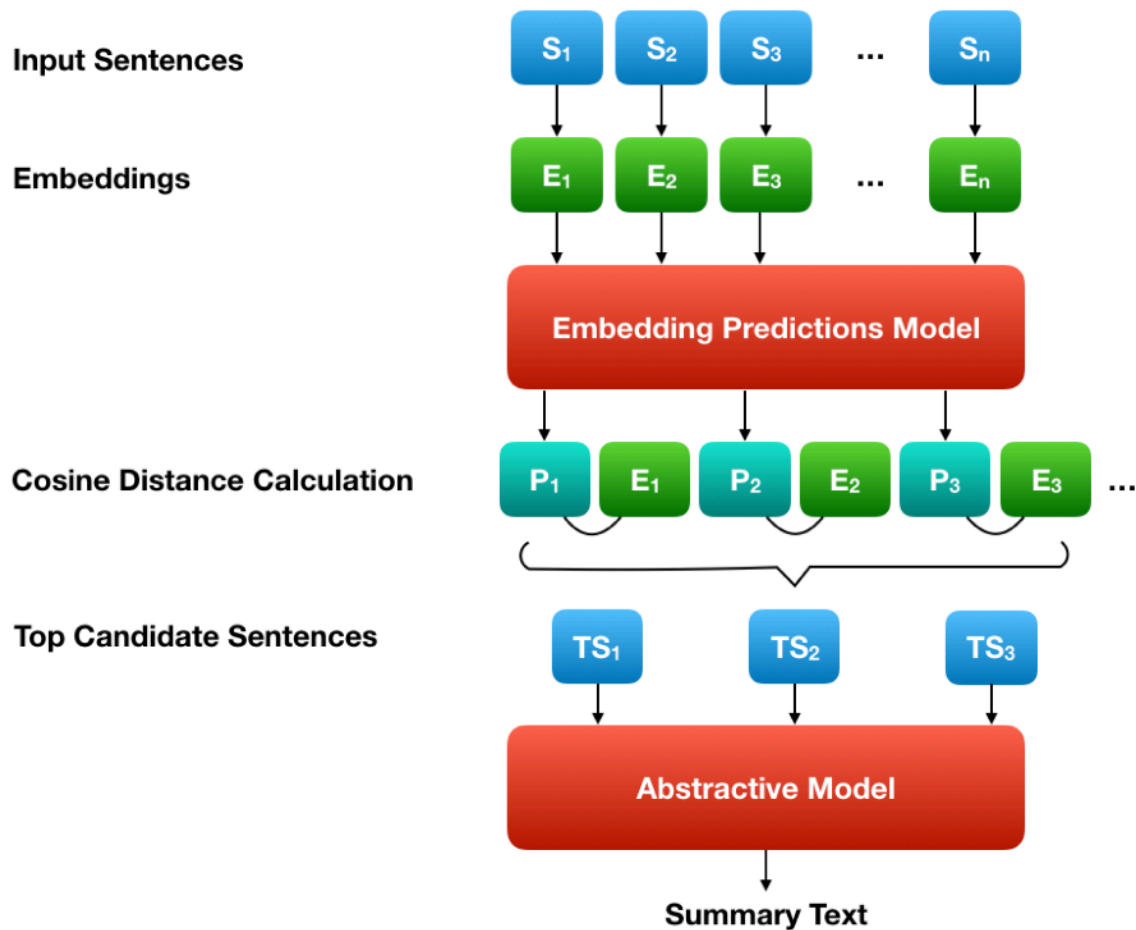
1. This hotel is a nice old **art - deco** building.
2. An **art deco** style hotel - this is unique!
3. Housed within a striking **Art Deco** building which dates back to **1932**, the Embassy Hotel is an **elegant** option with a **central position** in San Francisco.



A 1932 Art Deco  
hotel near cultural  
hotspots

# Sentence Score Calculation





Hotel Name	USP Text Output
Insula Alba Resort & Spa	Beautiful hotel with a modern amenities.
Leonardo Hotel Heidelberg	Well-equipped rooms with stunning city views.
Hyannis Holiday	Luxury amenities and convenient location.
Hotel Nomo Soho	Prestigious hotel with great views of Manhattan.

# But sometimes...

- Text-to-text ML summarisation can lead hallucinations or reporting factually incorrect information:
  - “Terrace pool with **romantic children's experience**” — Hallucination.
  - “On-site bar and restaurant **with food**” — Redundant information.
  - “Hi-rise hotel with **great views of the water**” — Factually incorrect. Accommodation is not directly near the water.
- Mitigated through:
  - Better training data.
  - Post-hoc symbolic rules to either penalise certain candidates or prevent phrasings to occur.
  - Lengthy development testing-refinement cycle until confidence in the system has been ascertained.

# Potential areas of NL4XAI in trivago

# **Alternative Accommodation Star Ratings**

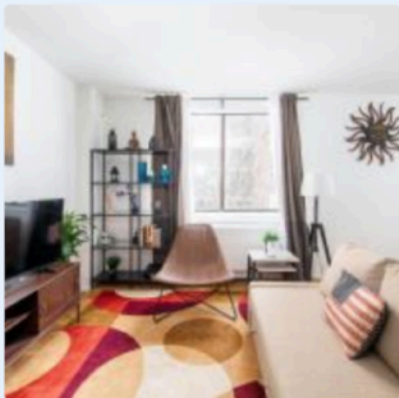


# Background

- Users are increasingly booking “alternative” forms of accommodation instead of traditional types such as Hotels, Hostels, etc.
- However, many alternative accommodations lack user based reviews.
  - In trivago’s case this is around 70% alternative accommodations.
- The lack of reviews makes it difficult for users to make informed decisions on whether to book a given alternative accommodation item or not.
- Therefore, an objective measure is required to allow users to judge the “quality” of a given alternative accommodation item.

# AA Star Rating

- Model that computes for each alternative accommodation item a star rating on a 1-5 scale.
- Uses objective features such as the types of amenities present, size, location, etc.
- Soon to be deployed into production for alternative accommodation items at trivago:



Apartment

## Athenas Domus # 3



.genius



Chelsea, New York

Awarded to **home and apartment-like properties** by Booking.com. These represent quality ratings based on factors including facilities, size, location and service.

Studio Apartment

**Sleeping arrangements:** 1 bedroom and a living room

**Beds:** 1 double bed  and 1 sofa bed 

**Size:** 12 m<sup>2</sup>

**Risk free:** You can cancel later, so lock in this great price today.

Superb

49 reviews

9.1

Location 10

Guest Favourite

3 nights, 2 adults

~~€ 963~~ € 872

includes taxes and charges

**FREE cancellation**

**No prepayment needed**

[See availability >](#)



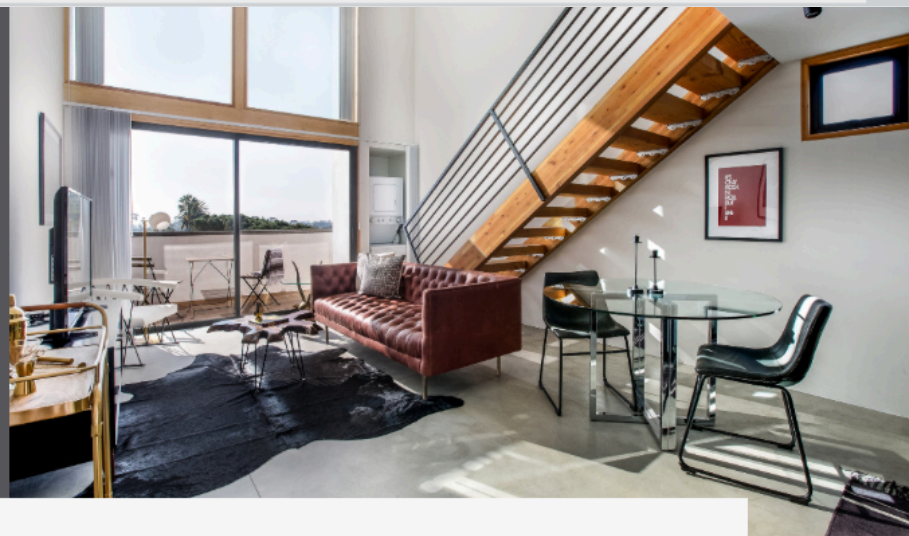
https://skift.com



Rooms, Rentals & Shares

# Booking.com's New Star Ratings for Short-Term Rentals Shake Sector

Sean O'Neill, Skift - Oct 15, 2019 12:30 pm



**Skift  
Take**

If you believe internet ratings, you'd think everything sold online is above average. Booking.com appears to be trying to combat that problem in the short-term rentals sector by rolling out a rating system. The company risks upsetting some property managers by acting as self-appointed judge and jury of unit quality. But some travelers may like the additional context.

— *Sean O'Neill*

# Natural Language Explanations Opportunities

- Scores generated by various comparison/booking sites for alternative accommodations are not directly comparable.
  - Different factors taking to account: Objective vs. Subjective.
  - trivago aims for broad AA star rating alignment with other sites in most cases.
- Natural Language Explanations can help the inform the user **why** a given accommodation is rated the way it is by describing the drivers and offsets:

*“This apartment was rated three stars due to featuring key amenities such as a gym and an open fireplace, but it is some distance away from the city centre.”*
- Such explanations could users by allowing them to more easily understand the rational for different ratings given for the same alternative accommodation item by different sites.

# Aspect Ratings

## Rating overview

9.2

**trivago Rating Index** based on  
3192 reviews across the web

Location		Excellent (8.8 / 10)
Rooms		Very good (8.1 / 10)
Service		Excellent (8.9 / 10)
Cleanliness		Excellent (8.9 / 10)
Value for money		Excellent (8.5 / 10)
Comfort		Excellent (8.9 / 10)
Facilities		Not rated yet
Building		Excellent (8.5 / 10)
Breakfast		Not rated yet
Food		Not rated yet

[- Show fewer](#)



# Aspect Ratings

- Scores for each aspect is gathered from many multiple sources and aggregated together to form the final score.
- Potential here to generate explanations on why a given aspect is rated with a particular score:
  - *“Guests highly rate breakfast at the Park Platz Hotel because of the unlimited coffee refills and generous portion sizes.”*
  - *“Comfort is highly rated at this hotel due to the comfortable bedding provided.”*
- Challenging as it requires inferring from user reviews to understand the causal reason for the ratings scores given.

# Marketplace Ranking

trivago.com

trivago

Log inMenuEUREN

Dusseldorf

Check in  
Wed, 11/13/19

Check out  
Thu, 11/14/19

Room  
Two-person r...

Search

Price / night

€500+

Accommodation

Guest rating

Hotel location

More filters

Sort by

Our recommendations

How payments to us affect ranking

Hotel NH Düsseldorf City

★★★★ Hotel

3rd Most Popular 4-Star Hotel in Düsseldorf

Düsseldorf, 0.5 miles to Hauptbahnhof Düsseldorf

7.7 Good (4278 reviews)

Good view · Very good food

NH Hotels

Hotels.com

Booking.com

More deals from

NH Hotels

€97

View Deal

InterContinental Düsseldorf

★★★★★ Hotel

Düsseldorf, 0.1 miles to Königsallee

8.9 Excellent (2559 reviews)

Very comfortable ·

InterContinental

Expedia

Trip.com

More deals from

Roomdi

InterContinental

Pay at the hotel

Open full screen map

Close map

LOHAUSEN

IRIA

Messe Düsseldorf

STOCKUM

Nordpark

DERENDORF

GOLZHEIM

DORF-LÖRICK

ERHOLUNGSSTÄTTE LÖRICK

DÜSSELDORF

LICHTENBROICH

MÖRSENBROICH

Wanheimer Str.

Theodorstraße

Unterstraße

An der Pöhlchen

An der Pöhlchen

Mörsenbroicher Weg

Lenaustraße

Rhein

trivago

68

# Marketplace Ranking

- Like many sites trivago tries to optimise the ranking of hotels to increase the likelihood of a user clicking on a deal.
- To recommend the best options to our visitors we try and take into account explicit and implicit user signals within a session (clicks, search refinement, filter usage) to detect the users' intent.
- Recommendations are updated to tailor the result list dynamically based on the users' intent and actions.



## Explanation of user actions in a sample session

user_id	session_id	timestamp	step	action_type	reference	platform	city	device	current_filters	impressions	prices
93F7WGHBP03A	569f5ea70df51	1541543231	1	search for destination	Barcelona, Spain	US	Barcelona, Spain	desktop			
93F7WGHBP03A	569f5ea70df51	1541543269	2	filter selection	Focus on Distance	US	Barcelona, Spain	desktop	Focus on Distance		
93F7WGHBP03A	569f5ea70df51	1541543269	3	search for poi	Port de Barcelona	US	Barcelona, Spain	desktop	Focus on Distance		
93F7WGHBP03A	569f5ea70df51	1541543371	4	interaction item deals	40255	US	Barcelona, Spain	desktop			
93F7WGHBP03A	569f5ea70df51	1541543425	5	clickout item	40255	US	Barcelona, Spain	desktop		6744 40181 40630 84610 2282416 1258693 974937 147509 128238 7998246 40255 3058538 1637385 40285 147502 921707 40849 6757 12770 893733 685091 147522 40708 860451 6819	162 91 218 190 176 365 272 159 139 240 136 5099 164 116 90 192 191 213 109 178 131 128 168 101 331
93F7WGHBP03A	569f5ea70df51	1541543741	6	search for item	81770	US	Barcelona, Spain	desktop			
93F7WGHBP03A	569f5ea70df51	1541543770	7	interaction item info	81770	US	Barcelona, Spain	desktop			
93F7WGHBP03A	569f5ea70df51	1541543813	8	clickout item	81770	US	Barcelona, Spain	desktop		6832 40396 6621784 40197 6743 147488 40635 6177052 6742 1319782 40763 945255 83855 39937 1870125 1354432 6812 82400 40181 6834 81770 5056102 40797 923935 40284	347 245 199 65 359 233 227 270 294 625 208 174 121 217 226 616 293 166 91 198 274 272 123 130 131

# Natural Language Explanations Opportunities

- The value of generating explanations for recommender systems is well understood (Tintarev and Masthoff, 2012).
- Explanations for Marketplace recommendations can allow users to better understand why accommodations are ranked in the given order.
- Gives users the opportunity to amend their explicit intent if the recommendations are not what they expected:
  - Reduces user friction / frustration.
  - Learning opportunity to fine tune performance of the Marketplace recommender system.

# Conclusion



# Conclusions

- Increasing change away from data being the “black box” to AI models.
- NLG can play a significant role in generating explanations for these models.
- However, deployment of industry NLG based solutions historically has not been without its challenges.
- At trivago we are making use of data-to-text and text-to-text NLG solutions and see strong potential for the use of natural language for generating explanations of AI models.

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