CONVERSATIONAL SYSTEMS RESEARCH IN SPAIN: A SCIENTOMETRIC APPROACH

PREPRINT

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ABSTRACT

The aim of this paper is to present a preliminary scientometric study of the area of conversational systems in Spain. In order to do so, we have used the Web of Science database to retrieve the papers in the area using a comprehensive list of keywords and considering those papers with at least one author with Spanish affiliation. Our results present an overview of the main topics, authors and institutions involved in conversational system research and show the good status of Spanish research in this discipline.

1 Introduction

Scientometrics is a research area that studies science, technology and innovation using quantitative approaches, e.g. by means of statistical mathematical methods [1]. This is usually achieved by studying peer-reviewed scientific publications and other related documents.

Scientometric indicators are very useful to provide evidence of scientific outcomes, achieve a general perspective of a field of research or even infer hot topics and emerging research fronts [2].

For example, the OECD has a section devoted to scientometric indicators to standardise, collect, report and analyse a wide range of science, technology and innovation activities[1] [3], including trends in scientific production (e.g. top cited publications, recent trends in scientific excellence, quantity and quality of scientific production, citation impact), scientific collaboration (e.g. patterns of international collaboration), and insights on scientific production and funding.

The general aim of the Plan for the Advancement of Language Technology[2] of the Digital Agenda for Spain is to promote the development of natural language processing, conversational interfaces and machine translation in Spanish and Spains co-official languages. The Plan has the following specific goals:

- Increasing the amount, quality and availability of linguistic infrastructure in Spanish and in Spains co-official languages.
- Fostering the language industry by promoting knowledge transfer from the research field to that industry and the internationalisation of companies and institutions in the sector; improving the reach of current projects.
- Improving the quality and capacity of public services, integrating natural language processing and machine translation technologies, simultaneously driving demand. Supporting creation, standardisation and distribution of language resources created by the management activities performed by the public administrations.

This paper contributes an initial scientometric analysis of research in conversational systems in Spain. In the scope of the Plan for the Advancement of Language Technology, the term conversational system is used to refer to computer applications that can hold a conversation in natural language [4]. This approach emphasises two key ideas. First, the use of natural language (written or spoken) as a support for communication. Second, that the system has conversational abilities and is able to interact in a series of turns in which it exchanges messages with the user in natural language.

There is a wide terminology related to conversational systems. The term chatbot is often used to describe systems that usually interact in text mode (through a chat), with which users can talk about any topic; while conversational and dialogue systems are sometimes used as synonyms. There is however a subtle distinction between a conversational system and a conversational agent. Usually, the term agent is used when the system appears to the user as an identifiable interlocutor. This usually happens with personified conversational agents, which have a physical appearance through avatars or other graphic representations; or robots, for which the term conversational robot is also used [5].

The development of a conversational system involves a large number of components that replicate the functions that human beings carry out to maintain a dialogue: recognise the sequence of words mentioned by the user (automatic speech recognition); extract the meaning of these words, that is, understand the information pieces that are useful in the domain of the system (natural language understanding); perform operations to access services, data repositories or other system resources, in which the information requested by the user is stored or the operations that they want to know are recorded; decide the next system action after each user request (dialogue management); reproduce a spoken message that informs the user about the action the system has selected (text-to-speech synthesis), and that it may be enriched by additional information pieces in other modalities [6].

There is a vast number of applications and tasks in which conversational systems can be applied, for instance: systems that provide information, healthcare systems, electronic banking services, tourism, industrial environments, applica-

[1] `https://www.oecd.org/sti/inno/scientometrics.htm`

[2] https://www.plantl.gob.es/

tions accessible from vehicles, systems that facilitate access to information for people with disabilities, tele-education applications, apps and personal assistants for mobile devices; access to services and control of machines using the telephone, home interaction and home automation control, interaction with robots and wearable devices, systems able of recognizing gestures and users' emotional states, etc.

For this study, we have focused the search of relevant pieces of work in different aspects that include the main terminology and related terms, technologies and components that are unequivocally related to conversational systems (e.g. dialogue management, but not speech recognition), functional systems and specific technology and the main tasks and application domains.

2 Method and sample

Our contribution is based on primary studies (articles, books and conference papers) indexed in Web of Science (WOS). To retrieve the papers related to conversational systems, we created a list of keywords that, from our point of view, could indicate that the research described falls into the area of conversational systems. The list of 176 keywords contains the main terminology, modules, technologies, approaches, domains and even names of already existing systems and can be found in the Annex.

We performed an advanced search in the Web of Science Core collection indicating that the topic (TS) can contain any of the keywords in the list and the country of affiliation (CU) of at least one author must be Spain (see the exact search query in the Annex). The publication timespan was "all years" (from 1900 to 2020), the date of recovery was 1st January 2020. With this search we retrieved a sample of 646 papers ($SAMPLE\_ES$).

For comparison purposes, we performed a similar query in which we did not restrict the country to Spain (we allowed publications from any country). We obtained a sample of 13,775 papers ($SAMPLE\_INT$).

It is important to note that when restricting to science only indexes (i.e. excluding social science indexes), the results are less significant, as relevant categories such as linguistics, educational research and behavioural sciences are missed. For example, the journal of the Spanish National Society for Language Processing (Procesamiento del Lenguaje Natural) is indexed under WOS category "Linguistics", and so it would not be considered if only science and technology sources are considered.

3 Discussion of results

The following subsections present an overview of the main areas, publishers and document types, authors and institutions involved in the items of conversational system research retrieved.

3.1 Areas

The top 20 Web of Science areas with more papers published from the Spanish sample are shown in Figure 1. As can be observed 67.49% (436) of the papers are published in the *Computer Science* area, and the top 5 areas are related to computer science, engineering, communications and robotic and automation. However, also in the top 10 we find other areas related to linguistics, education research and even pharmacology.

It is interesting to see areas related to pharmacology (43 papers), oncology (35 papers), geriatrics (32 papers) and general internal medicine (17 papers). When taking a closer look into the papers that fall into these categories, we find that they do not describe advances in the development of the conversational technology, but rather this technology is used to serve the health science research. For example, interactive voice response systems are used to randomly assign patients to different conditions (e.g. different drugs or drug vs. placebo) and administrate questionnaires.

In other areas (e.g. education and educational research) the conversational systems have a more prominent role, e.g. as key tools for second language learning, pedagogical agents or counsellors.

The results are similar to the international scenario (see Figure 2), in which 60,12% of the papers are in the *Computer Science* area. The top 3 are the same in both cases, and the main categories appear in the top positions of the ranking in both cases. However, it is interesting to note that internationally Psychology, Behavioural Sciences and Economics play a more relevant role than in the Spanish scenario. In the international scenario also educational research appears at a more discrete position compared to the Spanish scenario.

Figure 1: WOS areas of papers from $SAMPLE\_ES$

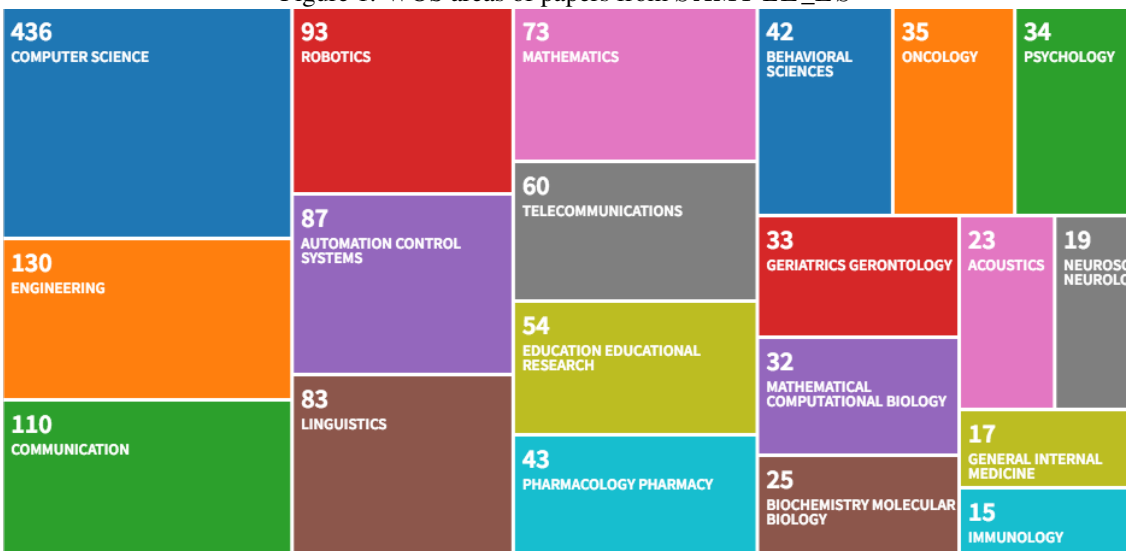
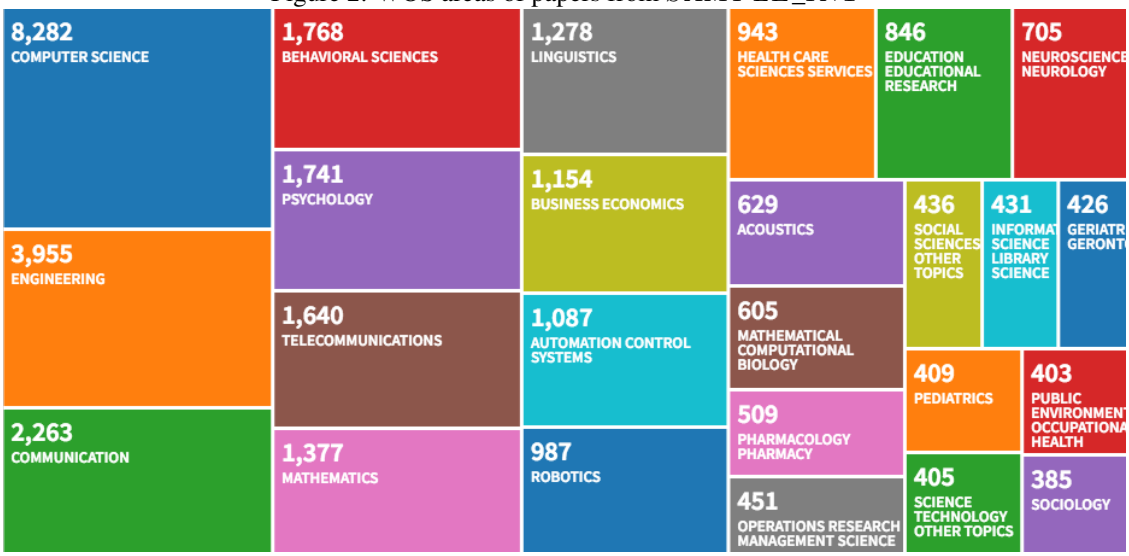


Figure 2: WOS areas of papers from $SAMPLE\_INT$



3.2 Publishers and document types

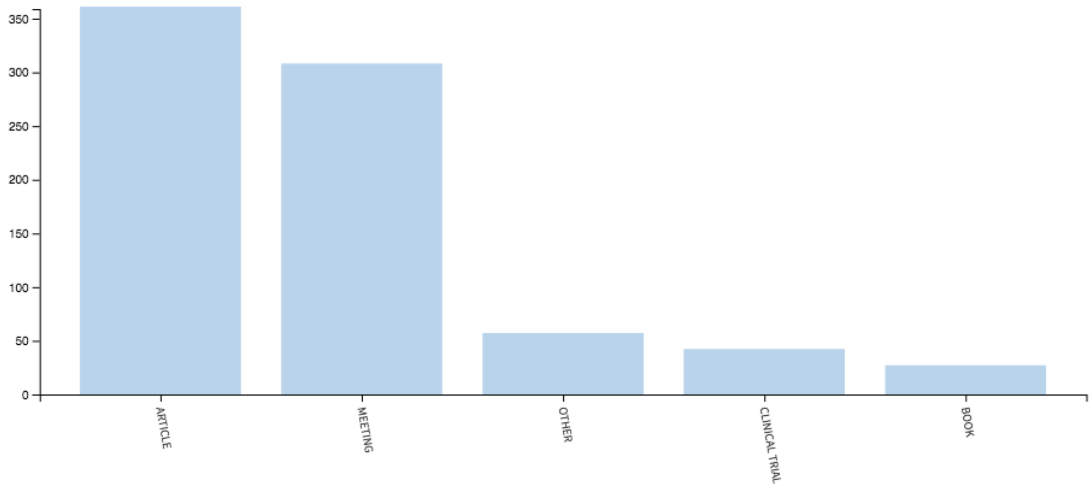
Regarding the type of publications, as shown in Figure 3, 55.57% are articles in journals and 47.37% publications in conference proceedings. Only 25 books or book chapters (3.87%) resulted from our query.

The percentages for all international publications ($SAMPLE\_INT$) are very similar (54.08% articles, 47.53% proceedings). This shows that Spanish authors publish article vs. proceeding papers at the same balance as international authors.

The sources with more publications in the Spanish list are Lectures Notes in Computer Science and Lecture Notes in Artificial Intelligence, which account for 18.73% of the records. It is very important to highlight that the third source (6.81% of the papers) is the journal Procesamiento del Lenguaje Natural, from the Spanish Society for Natural Language Processing (SEPLN).

Among the journals specialized in the area, the most representative are: Procesamiento del Lenguaje Natural, Speech Communication, Expert Systems with Applications, Ambient Intelligence and Smart Environments and Computer Speech and Language.

Figure 3: Document types of papers in $SAMPLE\_ES$



From conference series the ones with more papers from the $SAMPLE\_ES$ sample are Advances in Intelligent and Soft Computing, Advances in Intelligent Systems and Computing, Communications in Computer and Information Science. Regarding specific conferences, the most relevant are Text Speech and Dialogue (TSD) and Interspeech. It is also worth noticing the International Conference on Human-Computer Interaction (INTERACT), the Social Robotics International Conference (ICSR), the Artificial Intelligence in Education Conference (AIED), and the International Intelligent Environments (IE). The conferences organized in Spain with more publications from the sample are IberSpeech and the SEPLN annual conference. Also the workshop Future and Emergent Trends in Language Technology had an important impact.

Internationally, in the $SAMPLE\_INT$ sample, there also appear in the top 10 positions the International Conference on Acoustics Speech and Signal Processing (ICASSP) and the IEEE Workshop on Spoken Language Technology (SLT). The Journal of Pragmatics is in the 4th position.

3.3 Authors and affiliations

From the 21 authors with more than 15 papers (Figure 4) in $SAMPLE\_ES$, we can see there are strong publication records from authors who have had or have affiliations in Universidad Carlos III de Madrid (D. Griol, J.M. Molina, A. Sanchis), Universidad de Granada (D. Griol, R. López-Cózar, Z. Callejas, G. Espejo, N. Ábalos), Universidad Politécnica de Valencia (D. Griol, E. Sanchis, E. Segarra, L.F. Hurtado), Universidad Politécnica de Madrid (J. Ferreiros) and Universidad del País Vasco (M.I. Torres).

There exist more than 3k different affiliations in $SAMPLE\_ES$, from which only the universities mentioned in the previous paragraph produce more than 5% of the publications, being the most productive Universidad Carlos III de Madrid (22%), Universidad de Granada (17%) and Universidad Politécnica de Valencia (11%).

In the list of top-10 affiliations (see Figure 5) there also appear Universidad Politécnica de Madrid, Universidad de Sevilla, Universidad Politécnica de Cataluña, Universidad de Barcelona and Universidad de Zaragoza.

In $SAMPLE\_ES$ there are authors with affiliations from 75 countries (see Figure 6), which shows that Spanish authors in this field work in international teams with co-authors from other countries. The most representative countries are USA, UK, Italy, Germany and France.

As can be observed in Figure 7, Spain holds the 7th position at the international level (sample $SAMPLE\_INT$), with 4.70% of the publications. The most prolific authors are form USA, followed by UK, Germany and China.

Regarding individual authors, Figure 8 shows that 5 Spanish authors are among the 25 most productive internationally, and 4 of them in the first positions.

Figure 4: Most prolific Spanish authors in $SAMPLE\_ES$

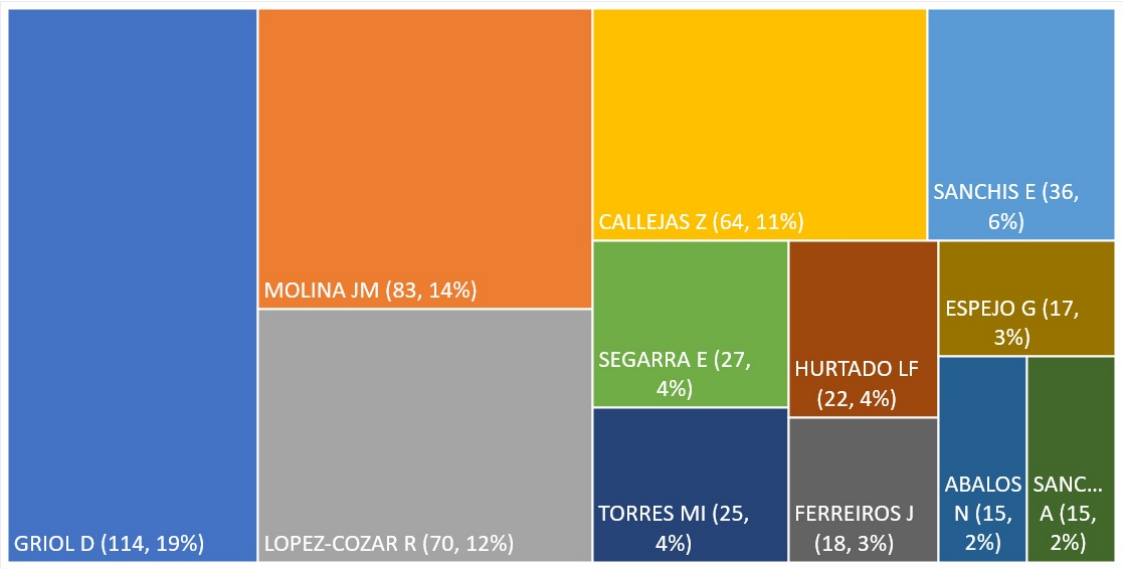
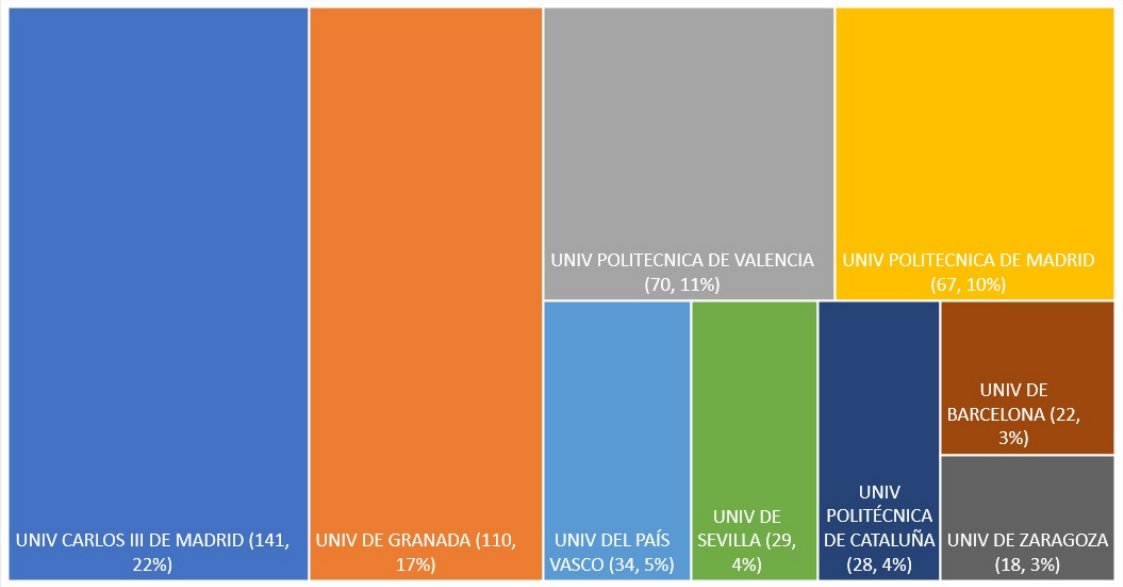


Figure 5: Most prolific Spanish institutions in $SAMPLE\_ES$



4 Conclusions and future work

This paper presents a preliminary scientometric study of the area of conversational systems in Spain. In order to do so, we have used the Web of Science database and retrieved the papers in the area using a comprehensive list of keywords and considering those papers with at least one author with Spanish affiliation.

Our results present an overview of the main areas, authors and institutions involved in conversational system research and show that the status of Spanish research in this discipline is significant and Spanish researchers occupy prominent positions in the rankings generated.

For future work we plan to extend the study considering co-citation, co-occurrence and altmetric indicators. We will also investigate the main collaboration networks between Spanish researchers and between Spanish and international researchers. For this new piece of work we will consider additional databases, such as Scopus, DBLP and Semantic Scholar.

Figure 6: International collaborations with Spanish authors

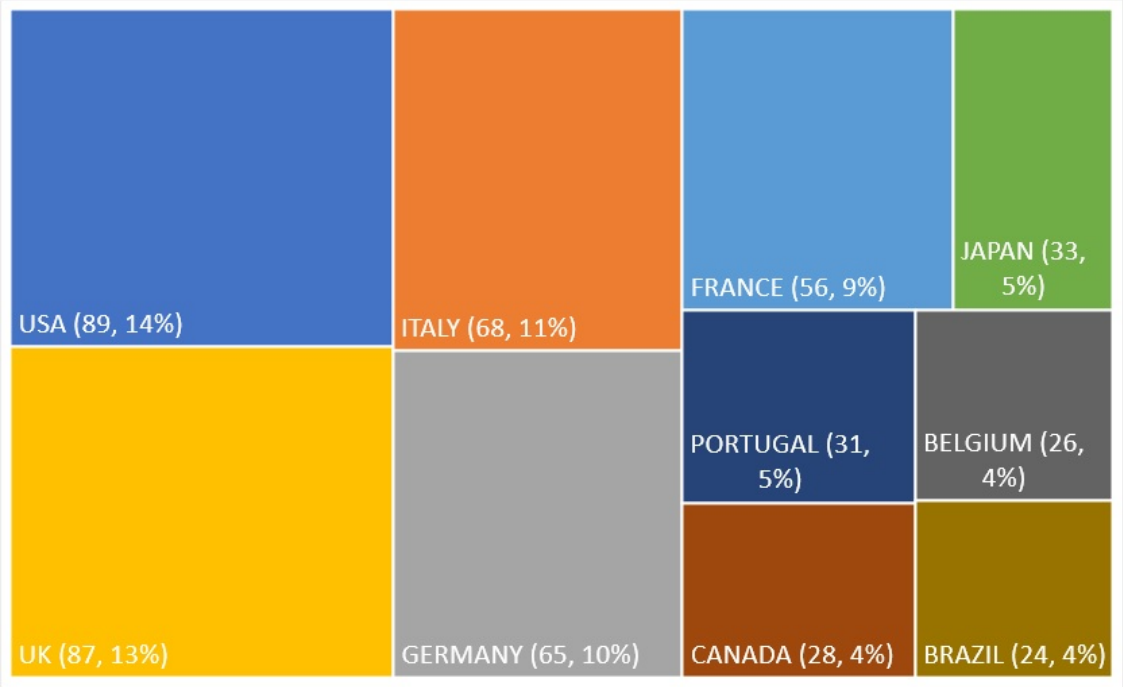
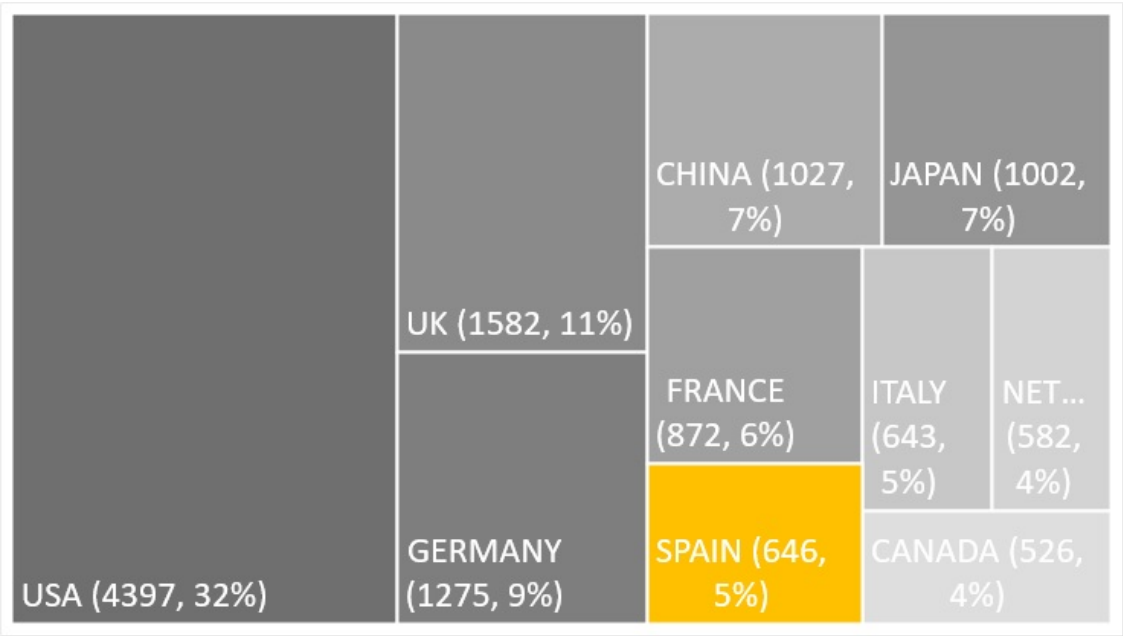


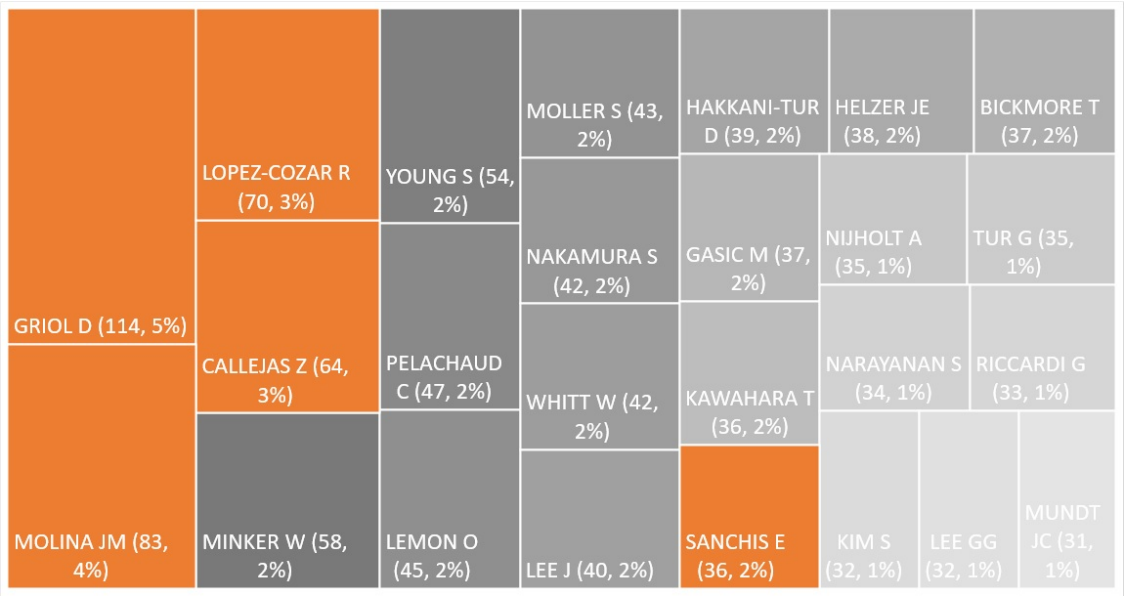
Figure 7: Most productive countries in the field



Annex

TS = (Acobot OR Airbud OR "Amazon Alexa" OR "Amazon Echo" OR "Amazon Lex" OR "Ambit AI" OR AmplifyReach OR "Android speech APIs" OR ApexChat OR Api.Ai OR Articbot OR AskSid OR Avaamo OR "BOTNATION AI" OR Boost.AI OR BotArtisanz OR Botkit OR Botsify OR BotXO OR "call center" OR "chat with dialogue" OR "chat dialogue" OR "chat with dialog" OR "chat dialog" OR chatbot OR ChatFuel OR "chatter bot" OR Cognigy.AI OR Conversica OR Cortana OR "conversational agent" OR "conversational AI" OR "conversational Artificial Intelligence" OR "conversational assistant" OR "conversational app" OR "conversational interface" OR "conversational applications" OR "conversational platform" OR "conversational robot" OR "conversational system" OR "conversational toys" OR "conversational web interface" OR "corpus-based dialog management" OR "corpus-based dialogue management" OR DAMSL OR "dialog bot" OR "dialogue bot" OR "dialog act" OR "dialogue act" OR "dialogue act modeling" OR "dialogue act classification" OR "dialog act recognition" OR "dialogue act recognition" OR "dialog act theory" OR "dialogue act theory" OR "dialog agent" OR "dialogue agent" OR "dialog assistant" OR "dialogue assistant" OR "dialog system" OR "dialogue system" OR

Figure 8: Most productive authors in the field (25 best in $SAMPLE\_INT$)



"dialog manager" OR "dialogue manager" OR "dialog management" OR "dialogue management" OR Dialogbot.ai OR Dialogflow OR DialogFlow OR "embodied conversational agent" OR "Embodied Conversational Agent" OR "end-to-end goal-oriented dialog" OR ENCollect OR Faqbot OR "finite state dialog" OR "Flow XO" OR Flow.ai OR "form interpretation algorithm" OR "frame-based dialog" OR "GALAXY architecture" OR "Google assistant" OR "Google Home" OR "Google Now" OR hellomybot OR HeyMojo OR Houndify OR "HubSpot's Chatbot Builder" OR Ideta OR InfinitAI OR "Information State Approach" OR "intelligent personal assistant" OR IntelliTicks OR "interactive speech systems" OR "interactive systems for speech" OR "Interactive Voice Response" OR "IOX bot" OR JeffreyAI OR Joey OR Kommunicate OR Landbot.io OR LiveEngage OR "mixed-initiative dialog" OR "mixed-initiative dialogue" OR MobileMonkey OR "multimodal conversational interfaces" OR "multimodal conversations" OR "multimodal dialog" OR "multimodal dialogue" OR "multimodal systems" OR "multimodal human computer interface" OR "multimodal interaction" OR "multimodal interfaces" OR "multilingual systems" OR nmodes OR Odus OR "Olympus architecture" OR "oral interface" OR PandoraBots OR "PARADISE project" OR "PARADISE paradigm" OR "PARADISE evaluation" OR PolyAI OR Polyfins OR "POMDP-based dialog" OR "POMDP-based dialogue" OR "POMDP dialog" OR "POMDP dialog management" OR "POMDP dialogue" OR "POMDP dialogue management" OR "question-answering from speech" OR "Rasa Stack" OR Ravenclaw OR Recast.AI OR "rule-based dialog management" OR SalesboxAI OR (Siri AND Apple) OR "slot filling dialog" OR "smart speakers" OR Smartloop OR SMARTKOM OR SmatBot OR Solvemate OR "spoken dialog system" OR "spoken dialogue system" OR "spoken dialog systems" OR "spoken dialogue systems" OR "spoken humancomputer interaction" OR "spoken question answering" OR "spoken virtual agents" OR "spoken virtual human toolkit" OR "statistical dialog management" OR Streebo OR supertext.ai OR Surbo OR "system-directed dialog" OR "technology of conversation" OR "Teneo" OR "Tilde.AI" OR "turn taking" OR "turn-taking" OR "Twyla" OR "vernacular.ai" OR "virtual personal assistant" OR "voice actions" OR "voice interface" OR "voice user interface" OR voicebot OR Voiceflow OR VoiceXML OR VOIQ OR Voxeo OR VUI OR "Web speech" OR Yekaliva OR Zynoviq) AND CU=Spain

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