BeeKnote: Voice Chatbot Assistant for the Beekeepers

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Education

- Student at Higher National School of Computer Science - ESI Algiers, Algeria (2018-2023)
  -Computer Systems and Software Specialty-

- Research intern in EFREI Research Lab, Panthéon Assas University, Paris, France

Publications and conferences

- "BeeKnote: Voice Chatbot Assistant for the Beekeepers" is actually my first conference presentation and my first research paper

Research Lines and area of interest

- Precision beekeeping
- Time Series analysis, forecasting and anomaly detection
- Deep Learning with Neural Networks
- Natural Language Processing and understanding (NLP/NLU)
- AI Software Engineering and Architectures

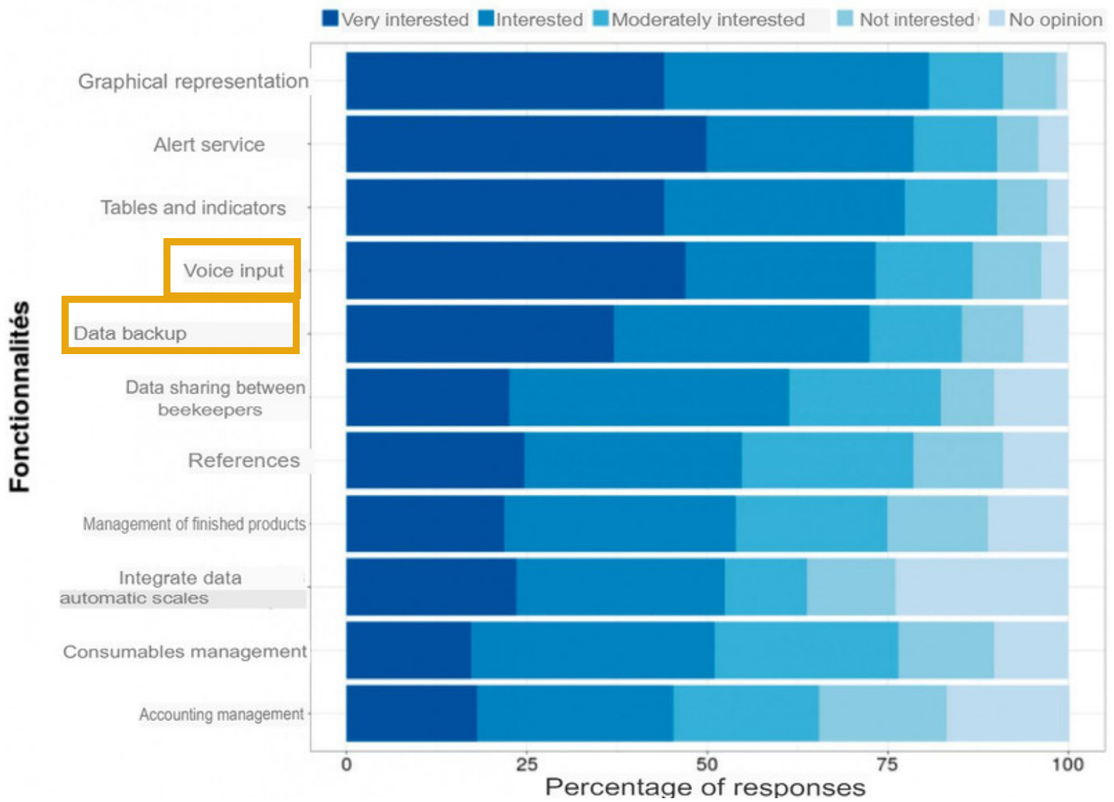
The presenter resume

1. Beekeeping's goal is having maximum yield with the minimum expense by providing the hive with a perfect environment that will ensure the maximum productivity of the bees that are inside

2. The human influence on the nature altered the balance of the bees natural process perfection :

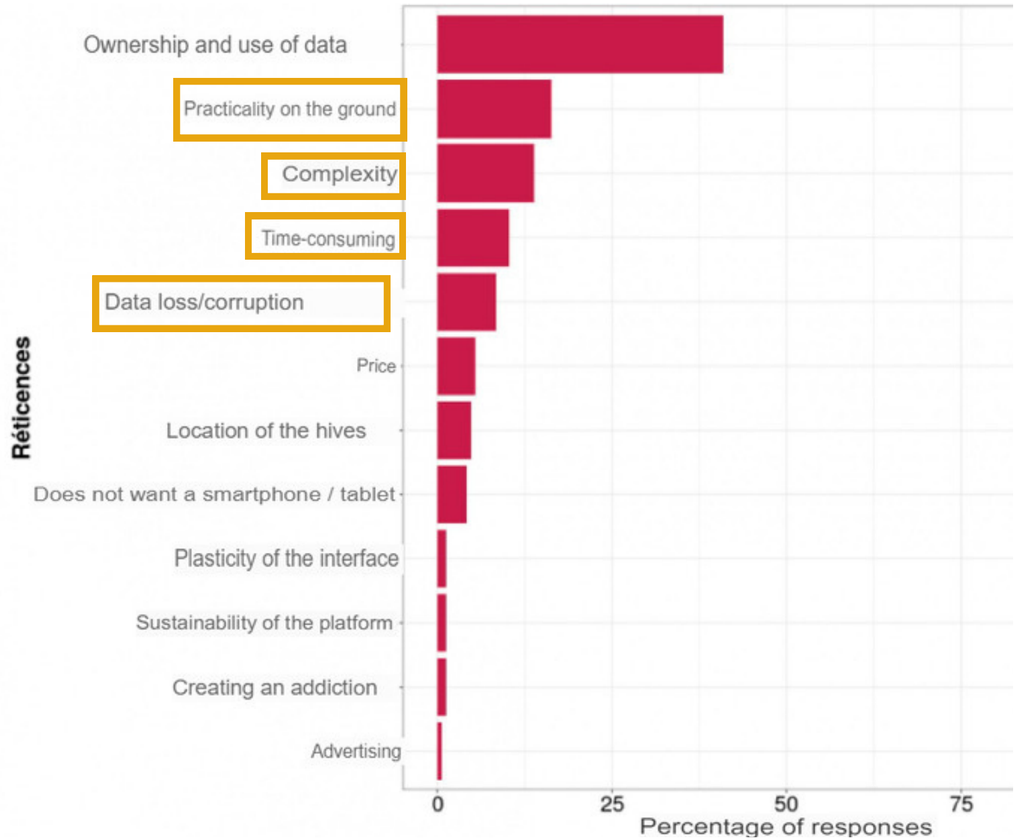
- In France, despite being considered one of the big producers of honey, the volumes of imported honey thus increased by 36% between 2010 and 2020 (Huet et al., 2022)
- the production of high-quality honey with an enough quantity becomes a more complex goal to be achieved for the bekeepers

3 Several studies have already proved the vocal assistant apps efficiency in the beekeeping field :



ITSAP-Bee Institute survey (ITSAP, 2020)

4 However, the usage of innovative technologies in the agriculture field (including the beekeepers) is still limited for some reasons (Symeonaki et al., 2021)



It's confirmed that a "Digital notes" app is considered a valid solution to fulfill "the Preservation of Bee colonies" and "minimizing the beehive inspections" which are among the top 3 most important areas for beekeepers (Zacepins et al., 2021).

"practicality in the field" , "the complexity of the developed solutions", and "the data loss or corruption" are considered the major factors of that.

In our paper, we aimed at:

1. Presenting a state of art about existing solutions as chatbot assistants for farmers and/or the beekeepers
2. Addressing the limitations of the existing solutions by proposing a new approach to enhance the customer experience and using it to develop "BeeKnote": the accurate user-friendly natural-language-based vocal assistant for the beekeepers

Contributions of our study are fourfold:

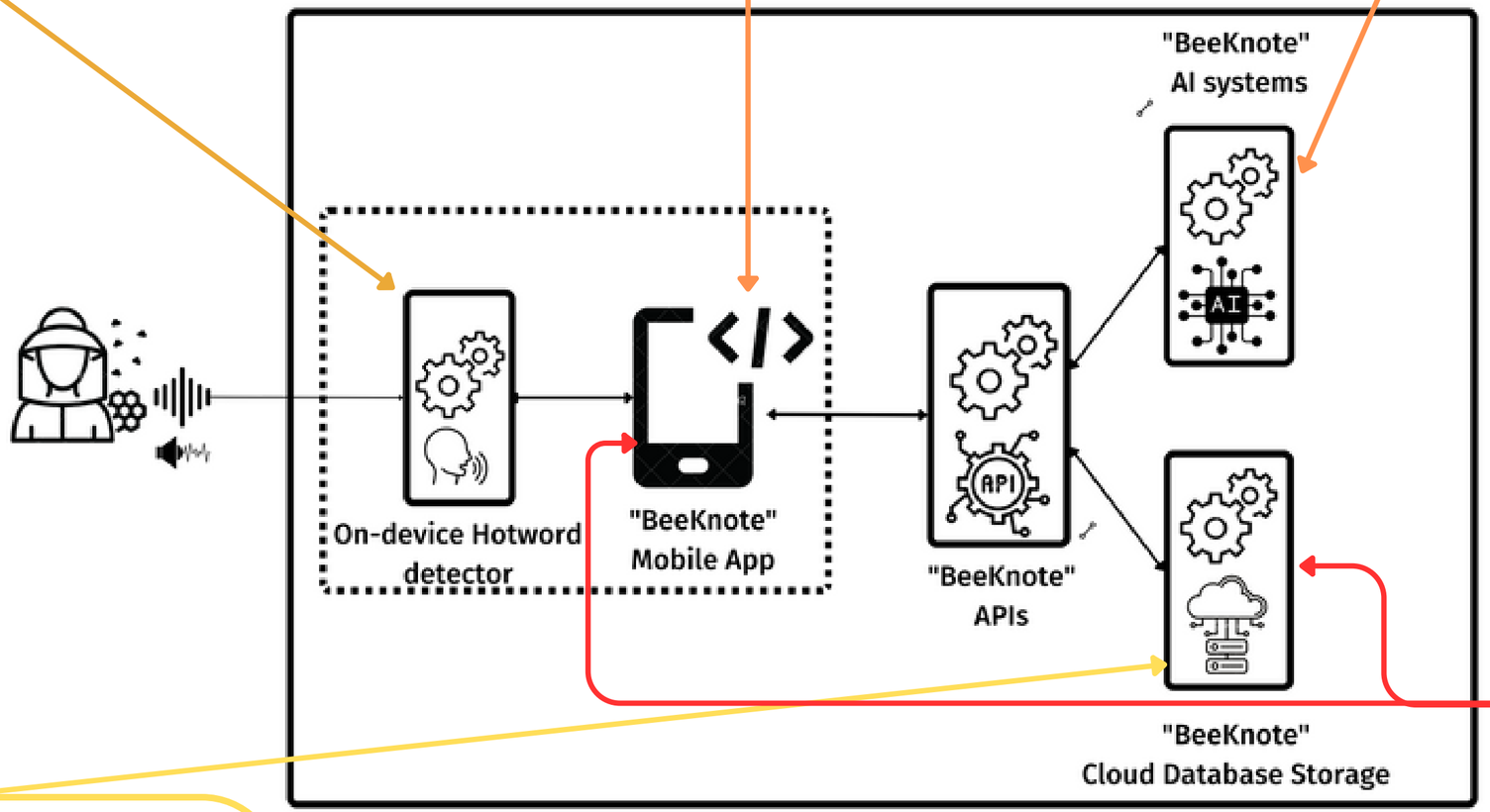
1. We explain our newly approach to assist the beekeepers on their work
2. We present the needed system components in order to achieve the proposed approach
3. We expose the final "Beeknote" System architecture and the workflow between its different compounents
4. We did unit testing and integration testing of the AI components to measure the overall accuracy of "BeeKnote"

	(Symeonaki et al., 2021)	(Oliveira Filho, 2021)	(Ferreira Mojaravscki, 2020)	(Gunawan et al., 2019)	(Zhang et al., 2021)	(Symeonaki et al., 2020)	("BeeKing," n.d.)	(S. Gaikwad et al., 2015)	(Devi & Dua, 2017)	**BeeKnote**
Human language communication	✓	✓		✓	✓	✓	✓	✓	✓	✓
Mobile devices support	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Database writing	✓					✓	✓			✓
Beekeeping-specific chatbot		✓	✓				✓			✓
NLP/NLU-based learning	✓	✓		✓	✓	✓		✓	✓	✓
Independent from IOT devices		✓			✓	✓	✓	✓	✓	✓
Independent from other messaging applications				✓		✓	✓	✓	✓	✓
Interaction with the user	✓	✓	✓	✓	✓	✓		✓	✓	✓
Vocal inputs support	✓						✓			✓
Vocal inputs understanding	✓									✓
Vocal hot-word detection										✓

3-Existed solutions as vocal/text assistants in beekeeping and/or agriculture field

4 Providing Hands-free experience

1 Recording and Understanding the beekeepers' vocal commands



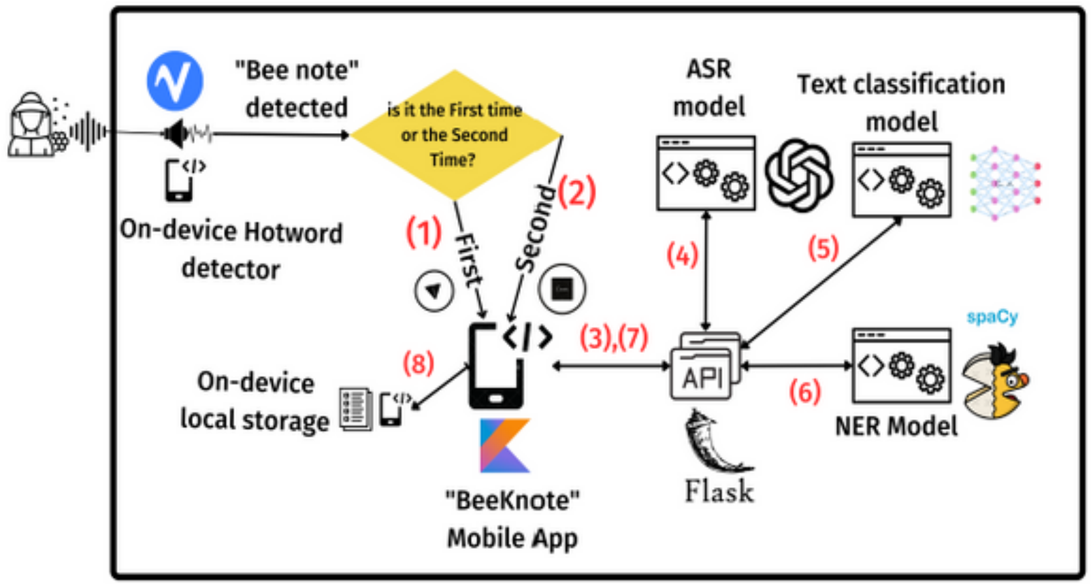
3 Cloud Storage of the vocal intent after the validation

2 Validation/Rejection of the command

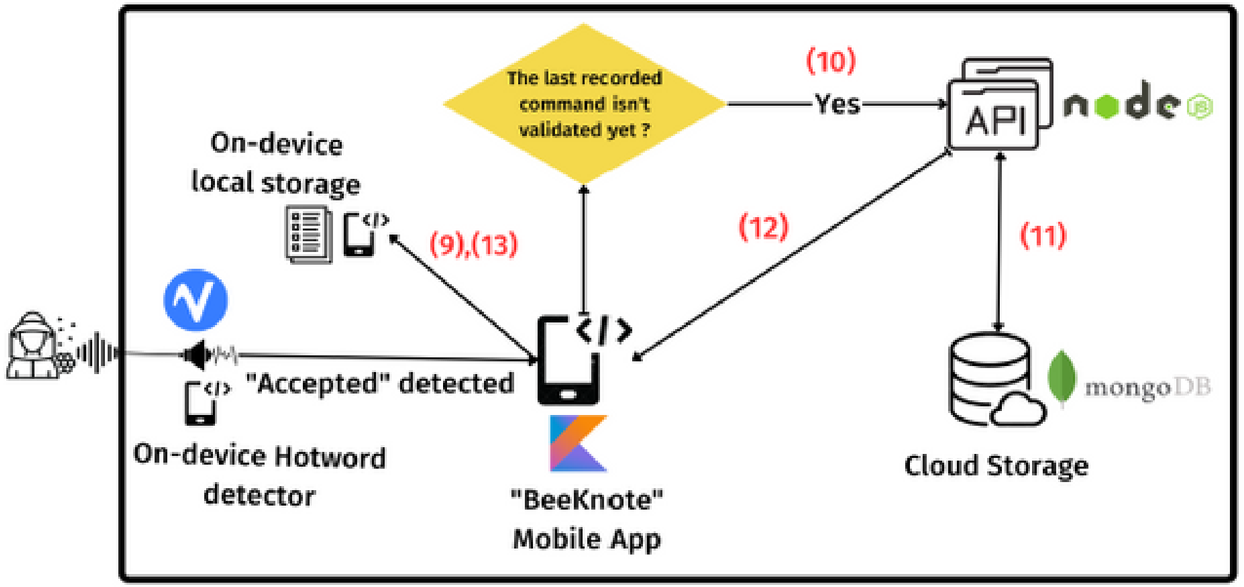
4-BeeKnote global architecture and proposed functionalities

Type	What ?	How ?	Comments
AI Systems	Automatic Speech Recognition (ASR)	Whisper AI	• It proves his performance for the French language compared to the alternative ones.
	Named Entity Recognizer (NER) system:	CamemBERT+ spaCy	• Training for our predefined entities (11 domain-specific entities that we need to extract)
	Text classification system :	Gated Recurrent Unit (GRU)	• Predicting the commands topic among four classes: "Weight", "Humidity", "Internal temperature", and "External temperature".
Hot-word Detector		Porcupine	• Lightweight and production-ready hot-word detector
Cloud Storage		MongoDB	/
APIs	API to communicate with the AI systems	Flask	• the AI models can be easily plugged, extended, and deployed as a web service there
	API to communicate with the cloud	NodeJS	/
Mobile Application		Android application (Kotlin)	/

5-BeeKnote System Components



Audio recording and understanding workflow



Command validation record

6-BeeKnote Workflow System Architecture

The used Dataset for training the Classifier and the NER systems :

1 Training data structure :

	Sentences	intent	annotation
65	J'ai laissé la ruche fermé, il y a beaucoup de condensation 85% d'humidité	humidité	[(beaucoup de condensation,HMD_DESCRIPTION);(85% d'humidité,HMD_VALUE)]
47	Il fait 40 degrés aujourd'hui	température ambiante (météo)	[(40 degrés,TEMP);(aujourd'hui,TIME_DESCRIPTION)]
50	On peut mesurer 14 degrés à l'extérieur	température ambiante (météo)	[(14 degrés,TEMP);(à l'extérieur,TEMP_EXT)]
42	Super, pas de changement de température	température interne (ruche)	[(pas de changement de température,TEMP_DESCRIPTION)]
57	La météo est bonne, 22 degrés c'est super cool	température ambiante (météo)	[(La météo est bonne,TEMP_EXT_DESCRIPTION);(22 degrés,TEMP)]
35	La température baisse dans la ruche	température interne (ruche)	[(La température baisse,TEMP_DESCRIPTION);(dans,TEMP_INTERNE)]
29	La ruche est très froide : 10 degrés	température interne (ruche)	[(très froide,TEMP_DESCRIPTION);(10 degrés,TEMP)]

- Each row contains the sentence to classify , its intent and annotation fo the information to extract
- Filled manually

2 Train/Test splitting

- Training : 75 rows (with 121 annotated entities)
- Testing : 26 vocal files : 8 for weight, 10 for temperature, and 8 for humidity containing 56 annotated to detect and to accurately classify it

The used test techniques :

1 Unit Testing :

Measures the unit accuracy test of each component independently

1. ASR System results
1. Text Classification system results
1. NER System results

2 Integration testing :

Measure the accuracy of the whole system by connecting the whole system’s components.

1 ASR System results:

Three versions of Whisper were used in our test database

Version	Perfect Transcriptions	Avg. Exec (s)
Base	42.3%	**0.328**
Medium	61.53%	1.03
Large	**76.92%**	1.49

We picked the ‘Large’ Whisper version for "BeeKnote", which has 76.92% of accuracy with an acceptable execution time

2 Text Classification system results:

Type	Classified correctly
Weight	75%
Temperature	70%
Humidity	75%
Total	73.07%

Results shows that our best classifier has an accuracy of around 70-75% for the three classes.

3 NER System results:

Two versions of CamemBERT were used to train our own NER System

Type	Detection		Accuraccy		Avg Exec (s)	
	Base	Large	Base	Large	Base	Large
Weight	100%	100%	**100%**	93%	**0.12**	0.32
Temperature	92%	**96%**	88%	**96%**	**0.10**	0.27
Humidity	**100%**	93%	81%	**87%**	**0.10**	0.27
Total	96%	96%	89%	**92%**	**0.10**	0.33

Reslults shows that although camemBERT-large is thrice slower, it has shown just a little improvement in the accuracy rate (3% more accurate).

Intermediate conclusion:

Our NER system performs so well that it doesn’t need the classification system to assure its consistency

Therefore, the generated transcription will be passed directly to our NER System

This will improve the beekeeper experience by allowing him to say a mixture of entities that don’t have to be on the same class

We passed the transcription generated by "Whisper-large’ to our NER systems "camemBERT-large" and "camemBERT-base"

WHISPER-LARGE INTEGRATION WITH CAMEMBERT-BASE VS WHISPER-LARGE INTEGRATION WITH CAMEMBERT-LARGE RESULTS

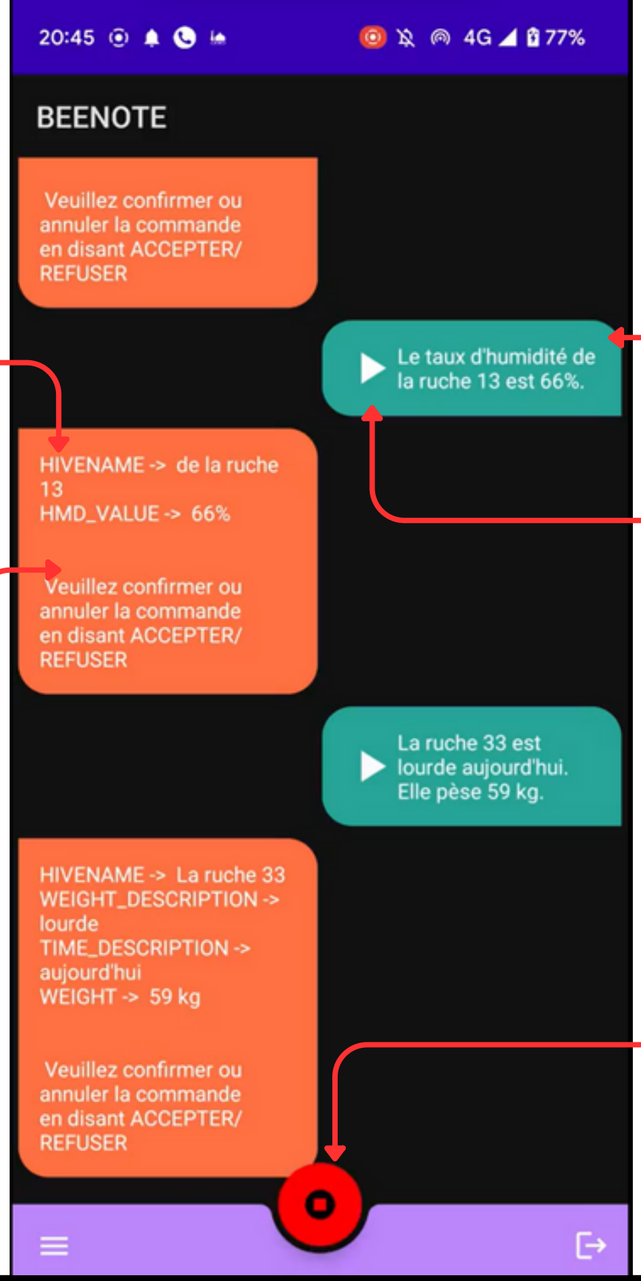
Type	Detection		Accuraccy		Avg Exec (s)	
	Base	Large	Base	Large	Base	Large
Weight	86%	80%	80%	80%	**+0.13**	+0.32
Temperature	92%	**92%**[1]	80%	**84%**	**+0.11**	+0.38
Humidity	**93%**	87%	**81%**	75%	**+0.10**	+0.52
Total	**91%**	87%	80%	80%	**+0.11**	+0.40

[1] There was a false positive detected entities here: 92% are true positive ones while there was additional 16% detected considered as false positive.

- Identical global accuracy (80%)
- Slight increase in the detection rate for the camemBERT-base (+3.5%) even though it was shown that the camemBERT-large has better accuracy in the unit testing section
- Possible explanation: camemBERT-large’s fault intolerance with the inaccurate transcriptions

Intermediate conclusion :

“Whipser-large" - "Camembert-Base" integration gives us : better detection rate, four times execution time improvement and fault tolerance



The extracted informations from the beekeeper last command

The Chatbot invites the beekeeper to say ACCEPTER/REFUSER for the validation/rejection

The generated Transcription from the beekeeper's command

Clickable icon to hear the recorded command

the Red Record icon tells the beekeeper that the mobile app have detected "Beenote" and it starts recording

Overall Conclusion :

- We developed "Beeknote", a smart system able to record and understand the beekeeper’s vocal inputs to extract relevant mentioned information related to the beehive state
- System powered by a hand-free experience to improve the beekeepers experience
- System with microservices shape to assure the flexibility.

Future work :

- Offline version support
- Boost our training data with data augmentation techniques to assure the understanding of the badly structured commands

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References

1 Automatic Speech recognition (ASR) :

We used "Whisper" which gives a WER equal to 8.3% in the "Fleurs" database for the French language [14], which proves his performance compared to the alternative ones.

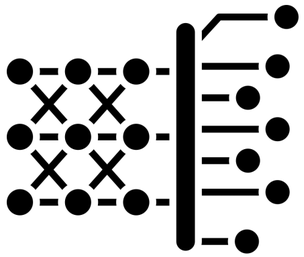
Whisper

2 Hot-word detection system :

We used "Porcupine" which is a lightweight and production-ready hot-word detector that shows the biggest accuracy (91%) in "work word benchmark" compared to two famous hot-word detectors: “Snowboy” (68%) and "PocketSphinx" (52%) [15]

3 Text classification system :

We built and trained a deep multi-classification bidirectional Global Recurrent Unit (GRU) neural architecture was built to do the training and the prediction of the commands topic among four classes: "Weight", "Humidity", "Internal temperature", and "External temperature".



4 Named Entity Recognizer (NER) system:

We used "CamemBERT" [16] to train our custom NER model for our predefined entities (11 domain-specific entities that we need to extract) in the French Language.

We used “SpaCy” [17] is used as a software library platform where "CamemBERT" was manipulated as a custom spaCy pipeline to train it in our data.

spaCy

Annex (Technologies justification: part 1)

5 First REST API (Flask) :

- This API plays the gateway role by providing an HTTP portal to communicate with the three previous AI systems (ASR, classification, and NER)
- We used "Flask” as a technology to implement this API since the AI models can be easily plugged, extended, and deployed as a web service there and it’s a lightweight server [18].

6 Cloud database storage:

- We used “MongoDB” as a technology to achieve data preservation due to its simplicity and its flexibility with the data structures, which will assure an easy future extension to our data schemas [19].

7 Second REST API (NodeJS):

- This API is the portal to communicate with the system cloud database by providing an HTTP interface for that
- We used "NodeJs” as a technology since it’s well-known for being fast and it allows us to explore a dynamic range of data in real-time easily [20]

8 The Android Application (BeeKnote)

- Our developed Android application will allow the beekeepers to exploit easily our three major functionalities previously mentioned by offering them an easy-to-use interface to communicate with our intelligent chatbot

Annex (Technologies justification: part 2)

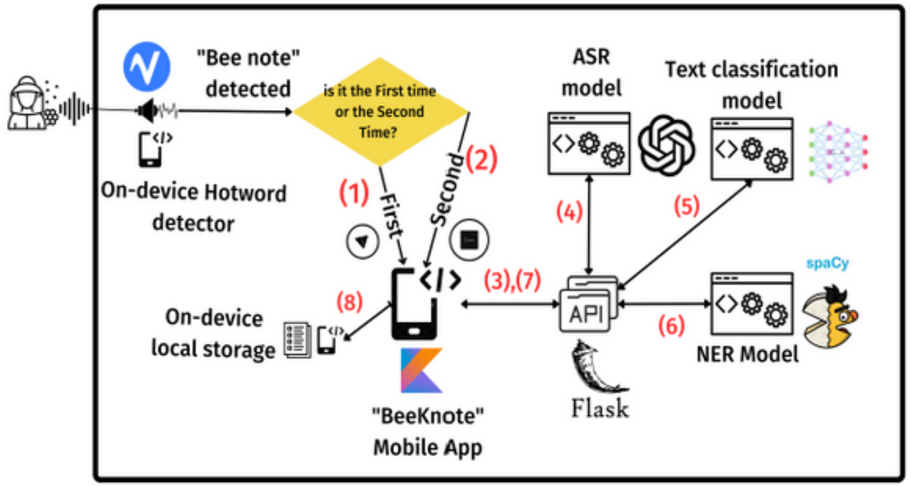


Figure 3. Audio Recording and Understanding Workflow

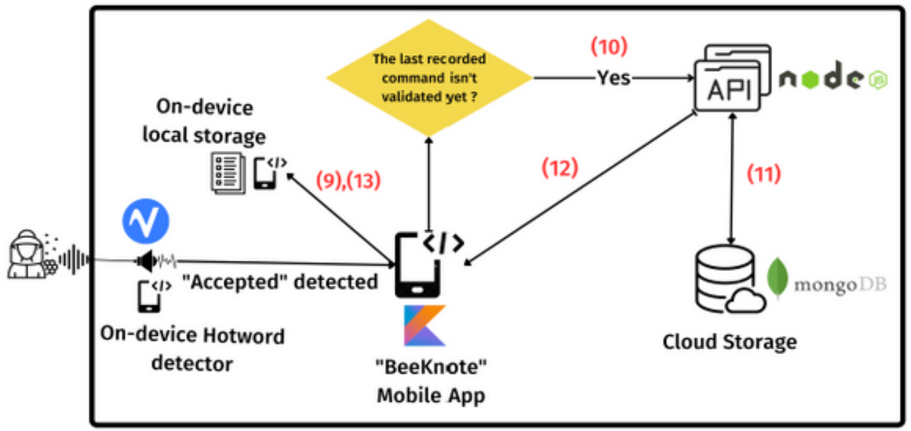


Figure 4. Command validation workflow

1. Starting the audio recording once the keyword "Bee note" is detected
2. Stopping the recording when the same keyword is detected again
3. Storing the recorded file locally + transmitting it to the FLASK API
4. Transmitting the .mp3 file to the ASR system as request and receiving the generated transcription as response
5. Transmitting the transcription to the text classifier system as request and receiving the predicted class as response
6. Transferring the transcription + the predicted class to NER system as request and receiving the detected entities and their classes
7. Transmitting the transcription, the predicted class, and the detected entities to the Android App
8. Storing the coming response in the local storage, waiting for the beekeeper validation
9. Gathering the latest recorded command onfo once the keyword "Accepted" detected
10. If it's not validated yet, it will be transmitted to the NodeJS API.
11. Storing the vocal command and the extracted information remotely in mongoDB
12. Confirming the sucess of the cloud storage
13. Toggling the latest record status from "pending" to "validated", locally

Annex (BeeKnote Workflow System Architecture with details)