Conversational Agents

Human-AI Interaction

Luigi De Russis, Tommaso Calò

Politecnico di Torino

1859

Academic Year 2025/2026

e-Lite

Background: Voice and Speech

Voice and Speech

- Human voice is an efficient input modality: it allows people to give commands to a computer quickly, on their own terms
  - speech is language dependent and it may be ambiguous
- Fully understanding natural language remains a dream (for now)
- Voice and speech interaction became mainstream, in recent years
  - thanks to Siri, Google Assistant, Alexa, …
- Such applications simulate a natural language interaction at different extents
  - they require users to speak a restricted set of spoken commands that users have to learn and remember

Voice-based Interaction

- From a computer perspective, voice-based interaction is mainly:
  - speech recognition (speech-to-text)
  - speech synthesis (text-to-speech)
- Applications may leverage one or both
  - in some cases, Natural Language Processing (or Understanding, NLU) is added
- Examples:
  - https://dictation.io/
  - https://translate.google.com

Voice-based Interaction: Opportunities

- Spoken interaction is successful in some cases…
  - When users have physical impairments (also temporary)
  - When the speaker’s hands are busy
  - When mobility is required
  - When the speaker’s eyes are occupied
  - When harsh or cramped conditions preclude use of a keyboard
  - When application domain vocabulary and tasks is limited
  - When the user is unable to read or write (e.g., children)

Voice-based Interaction: Obstacles

- … and it encounters some issues, as well
  - Interference from noisy environments (and poor-quality microphones)
  - Commands need to be learned and remembered
  - Recognition may be challenged by strong accents or unusual vocabulary
  - Talking is not always acceptable (e.g., in shared office, during meetings)… also for privacy issues
  - Error correction can be time consuming
  - Increased cognitive load compared to typing or pointing
  - Some operations (e.g., math or programming) are difficult without extreme customization
  - Slow pace of speech output when compared to visual displays
  - Ephemeral nature of speech

Designing Conversational Interactions

1. Initiation
   - pressing a button, saying a "wake word", …
2. Knowing what to say
   - learnability is one of the main issues of technologies that mimics natural language
3. Recognition errors (speech-to-text)
   - they will happen… e.g., dime/time
4. Correcting errors
5. Mapping to possible actions
   - mapping the recognized sentence/context to the "right" action is one of most difficult parts
6. Feedback and dialogs
   - to recover from errors, to be sure to start the "right" action, …

Conversational Agents

… and their User Interfaces

Voice User Interfaces

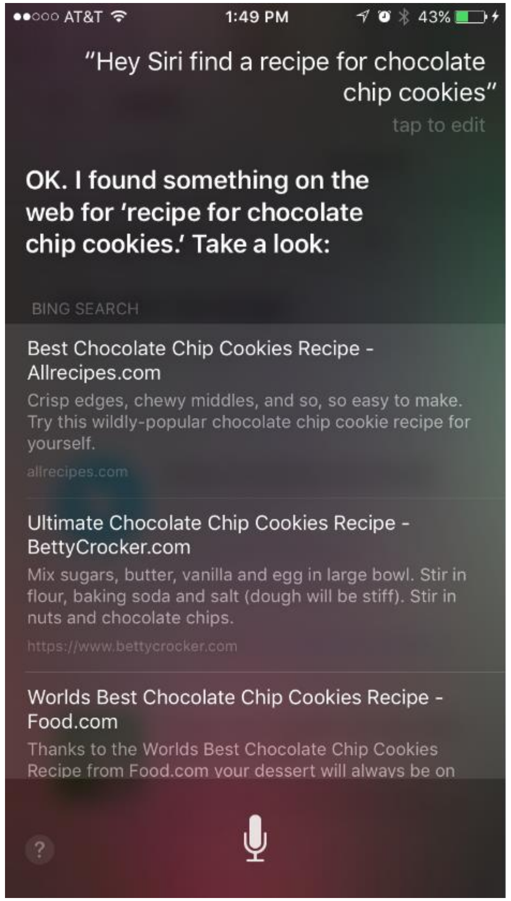
- Voice User Interfaces (VUIs) allow the user to interact with a system through voice or speech commands
  - primary advantage: hands-free, possibly eyes-free interaction
- Voice User Interfaces or Conversational User Interfaces?
  - "*which mimics a conversation with humans*"
  - "conversational" applies to both text-based chatbots and VUIs
- Contemporary VUIs can be divided in:
  - screen-first systems
  - voice-only systems
  - voice-first systems

Screen-First Devices

- Most of contemporary voice interaction happens on screen-first devices
  - smartphones, mainly
- Impressive speech recognition and language processing features
  - but overall experience is fragmented
- Main limitations
  - missing functionality
  - poor use of screen space while speaking
  - missing affordances

Missing Functionality and Affordances

- Users can start a task via voice, but subsequent steps require them to use the touchscreen
- Visual affordances are missing (or poor)
  - Siri omits several visual affordances (e.g., it does not show that people can edit a text message before sending it)
  - Google Assistant is better in this



"Hey Siri find a recipe for chocolate chip cookies"

tap to edit

OK. I found something on the web for 'recipe for chocolate chip cookies.' Take a look:

BING SEARCH

Best Chocolate Chip Cookies Recipe - Allrecipes.com

Crisp edges, chewy middles, and so, so easy to make. Try this wildly-popular chocolate chip cookie recipe for yourself.

allrecipes.com

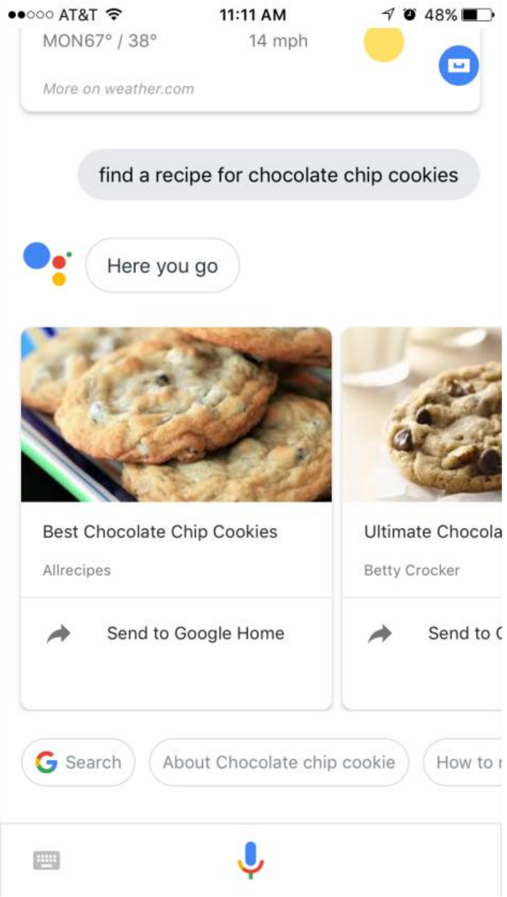
Ultimate Chocolate Chip Cookies Recipe - BettyCrocker.com

Mix sugars, butter, vanilla and egg in large bowl. Stir in flour, baking soda and salt (dough will be stiff). Stir in nuts and chocolate chips.

https://www.bettycrocker.com

Worlds Best Chocolate Chip Cookies Recipe - Food.com

Thanks to the Worlds Best Chocolate Chip Cookies Recipe from Food.com your dessert will always be on



find a recipe for chocolate chip cookies

Here you go

Best Chocolate Chip Cookies

Allrecipes

Send to Google Home

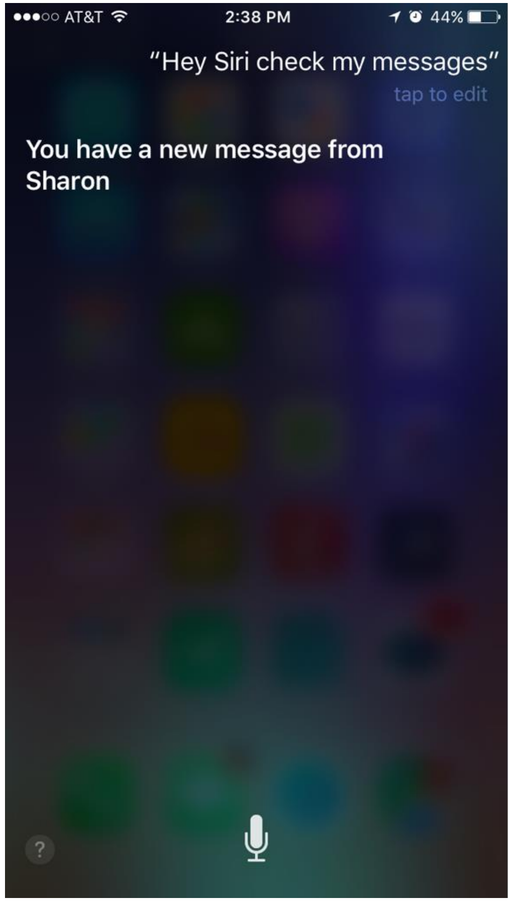
Ultimate Chocola

Betty Crocker

Send to (

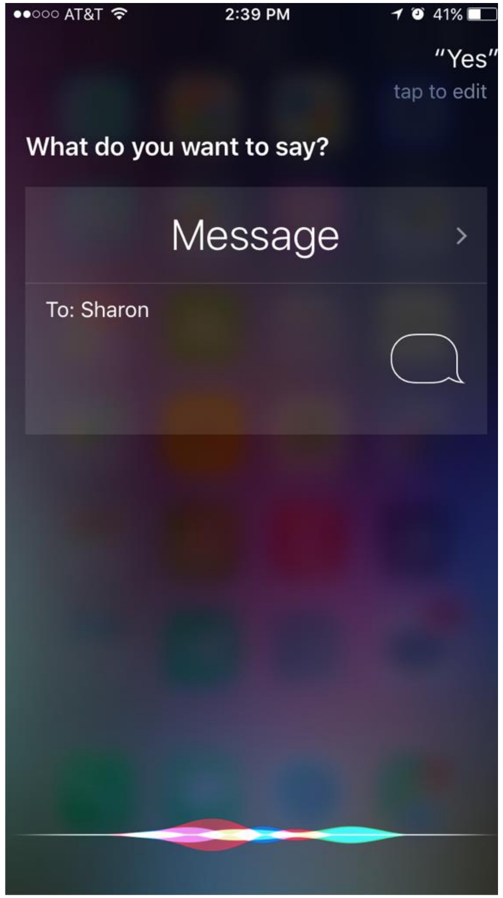
Poor Screen Space Use

- Tasks with some support for multi-step voice input exhibit a screen design:
  - totally different from the "normal" GUI version
  - which limits the information available to the user



“Hey Siri check my messages”

You have a new message from Sharon



“Yes”

What do you want to say?

Message

To: Sharon

Voice-Only Devices

- No visual display at all
  - like the Amazon Echo
  - audio is for input **and** output (plus some "feedback lights")
  - hands-free operation
- Quite good accuracy in speech recognition
  - if you do not mix different languages in a sentence
  - auditory signals are the only used cues (no visual affordances)

Voice-Only Devices: Limitations

- They are quite prolix in the answers
- You have to know what to say!
- Some operations are "challenging", e.g.,
  - once a timer is set up, the user can only *ask* how much time is left
  - getting a weekly weather forecast is a… memory test
- Some actions are not allowed nor expected, e.g.,
  - you cannot insert your wifi password, vocally
  - you cannot hear about all the available (and installable) skills

Voice-First Devices

- Voice-only devices… with a screen
- A system which primarily accept user input via voice commands, and **may** augment audio output with visual information
  - no differences from the "voice" perspective
  - GUI is less capable than the one in screen-first devices
- Typically, the display is a touch screen
  - but it rarely provides buttons or menus
  - the focus is still on voice

Say My Name - Tove Styrke
music
Say my name
Wear it out like a sweater
that you love
'Cause I can't get enough
when you
LYRICS

Designing Conversational Agents

… and their UI

Designing Conversational UI

- Voice interaction between people and devices is analogous to learning a foreign languages
  - both for users and designers/developers
- Easily learnt through **immersion**
  - voice-first devices have an advantage in this
- Successful examples on voice-first devices:
  - sequential numbering of search results
  - randomly show new speech commands
  - voice-accessible interactive (visual) content
- Beware: people often have unrealistic expectations
  - they think a VUI as a "natural conversation partner"

Designing Conversational UI

- Before designing a conversational UI, you must always ask yourself: is conversation the right fit?
  - People already speak about those things? Is the interaction brief? Will a GUI require multiple taps/clicks to perform the same actions? People can do this while multitasking? …?
- To design a conversational UI, you firstly need to have a clear picture of
  - who is communicating, i.e., who are your users
  - what they are communicating about, what they will ask about, i.e., what their needs are
  - how they are communicating (by voice, by text, etc.)
  - what is their context?

Designing Conversational UI

- Then, you can write some **sample dialogs** and sketch **a diagram of the conversation flow**
  - both convey the flow that the user will actually experience
  - you can start with some key use cases
  - you can also informally experiment with and evaluate different strategies
    - e.g., is it better to confirm a user's request with an implicit confirmation or an explicit one?
- Focus on the **natural-language conversation** before considering any visual element
  - imagine to work with a voice-only device
- Example: https://developers.google.com/assistant/conversation-design/write-sample-dialogs

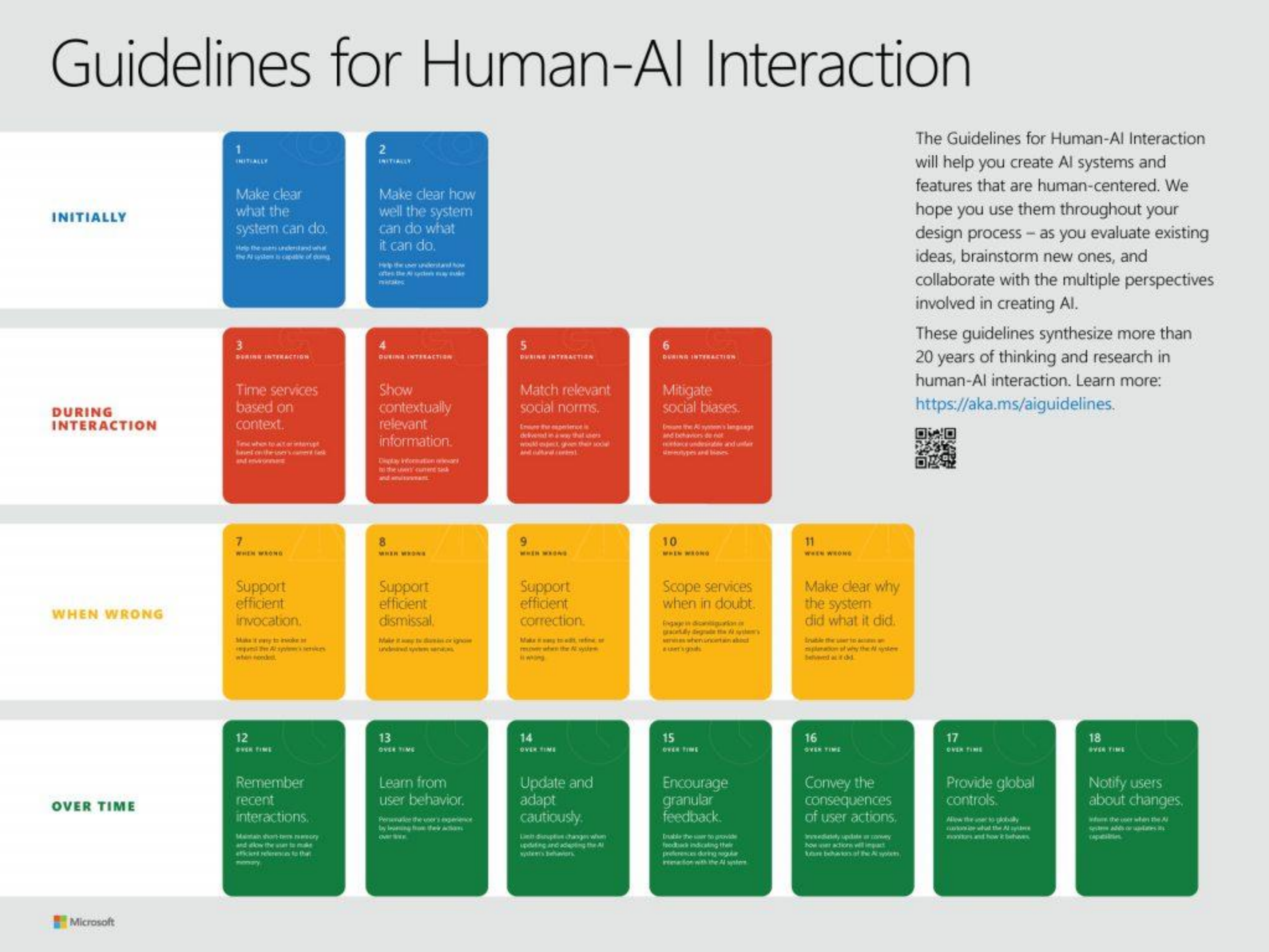
Basic Conversational Frames

- **Controlling**: specifying a goal with means of achieving it
  - "Play Radio Deejay from TuneIn"
- **Delegating**: asking for an outcome without specifying how to achieve it
  - "Play some jazz music"
- **Guiding**: discussing the means of achieving a goal
  - "I want to hear some music, how should I do it?"
- **Collaborating**: mutually deciding on goals between both participants
  - "What should we do?"

Currently adopted by contemporary VUIs

Guidelines

- By Microsoft Research
  - https://www.microsoft.com/en-us/research/project/guidelines-for-human-ai-interaction/
- Saleema Amershi et al. Guidelines for Human-AI Interaction. ACM CHI 2019
  - https://doi.org/10.1145/3290605.3300233



Guidelines for Human-AI Interaction

INITIALLY

1 INITIALLY
Make clear what the system can do.
Help the users understand what the AI system is capable of doing.

2 INITIALLY
Make clear how well the system can do what it can do.
Help the user understand how often the AI system may make mistakes.

DURING INTERACTION

3 DURING INTERACTION
Time services based on context.
Time when to act or interrupt based on the user's current task and environment.

4 DURING INTERACTION
Show contextually relevant information.
Display information relevant to the users' current task and environment.

5 DURING INTERACTION
Match relevant social norms.
Ensure the experience is delivered in a way that users would expect, given their social and cultural context.

6 DURING INTERACTION
Mitigate social biases.
Ensure the AI system's language and behaviors do not reinforce undesirable and unfair stereotypes and biases.

WHEN WRONG

7 WHEN WRONG
Support efficient invocation.
Make it easy to invoke or request the AI system's services when needed.

8 WHEN WRONG
Support efficient dismissal.
Make it easy to dismiss or ignore undesired system services.

9 WHEN WRONG
Support efficient correction.
Make it easy to edit, refine, or recover when the AI system is wrong.

10 WHEN WRONG
Scope services when in doubt.
Engage in disambiguation or gracefully degrade the AI system's services when uncertain about a user's goals.

11 WHEN WRONG
Make clear why the system did what it did.
Enable the user to access an explanation of why the AI system behaved as it did.

OVER TIME

12 OVER TIME
Remember recent interactions.
Maintain short-term memory and allow the user to make efficient references to that memory.

13 OVER TIME
Learn from user behavior.
Personalize the user's experience by learning from their actions over time.

14 OVER TIME
Update and adapt cautiously.
Limit disruptive changes when updating and adapting the AI system's behaviors.

15 OVER TIME
Encourage granular feedback.
Enable the user to provide feedback indicating their preferences during regular interaction with the AI system.

16 OVER TIME
Convey the consequences of user actions.
Immediately update or convey how user actions will impact future behaviors of the AI system.

17 OVER TIME
Provide global controls.
Allow the user to globally customize what the AI system monitors and how it behaves.

18 OVER TIME
Notify users about changes.
Inform the user when the AI system adds or updates its capabilities.

The Guidelines for Human-AI Interaction will help you create AI systems and features that are human-centered. We hope you use them throughout your design process – as you evaluate existing ideas, brainstorm new ones, and collaborate with the multiple perspectives involved in creating AI.

These guidelines synthesize more than 20 years of thinking and research in human-AI interaction. Learn more: https://aka.ms/aiguidelines.

Microsoft

A Use Case, Two Flavors

Movie App: let’s “chat” about movies

Movie App

- Let's build a web app for talking about movies
  - titles, genres, durations, …

- Two versions
  1. With a conversational platform
  2. With ChatGPT

- Basic requirements: knowledge of Python 3.x and web technologies

Conversational Platforms

- Natural language understanding platforms
  - for developers, mainly
  - typically cloud-based
- To design and integrate voice user interfaces into mobile apps, web applications, devices, …
- Focus on simplicity and abstraction
  - no knowledge of NLP required

Conversational Platforms

- Two main families:
  1. Extension of a product
     - they need an existing product (software and/or hardware) to work
     - e.g., Actions on Google or Skills for Amazon Echo
  2. Standalone services
     - a series of facilities to create a wide range of conversational interfaces in one platform, *typically* integrated in "suites" of cloud services
     - e.g., Dialogflow, IBM Watson, wit.ai, …

RASA

- "Build ML-powered Conversational AI"
  - https://rasa.community
- Open-source framework for building text- and voice-based applications
  - Commercial versions available as well
- SDK for Python (3.x)

DialogFlow

Dialogflow

- "Build natural and rich conversational experiences"
  - https://dialogflow.cloud.google.com/
- California-based startup, founded in 2010, acquired by Google in 2016
  - previously known as api.ai
- Free to use for simple usage
  - Two versions: ES and CX
- Multiple languages support
  - English, Dutch, Italian, Chinese, …
- REST API and various (official) SDKs
  - C++, C#, Go, Java, Node.js, PHP, Python, and Ruby

DialogFlow ES: Definitions

- Each application (an agent) will have different **entities** and **intents**
- Intent
  - a mapping between what a user says and what action should be taken by the agent
- Typically, an intent is composed by:
  - What a user says
  - An action
  - A response
- Different out-of-the-box intents can be enabled on DialogFlow

DialogFlow ES: Definitions

- Entities
  - represent *concepts*
  - serve for extracting parameter values from natural language inputs
  - should be created only for concepts that require actionable data
- Many pre-existing entities are available on the platform

Movie App Prototype with DialogFlow

- Base implementation:
  - https://github.com/luigidr/dialogflow-movies
- HTML+CSS+JS and Python
  - with a webserver in Flask
- Uses the Dialogflow v2 library
  - `google-cloud-dialogflow`

Get the Client Secret

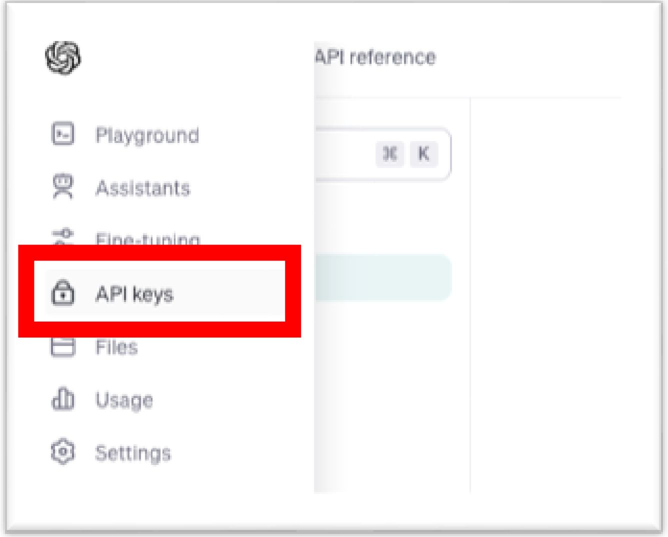
- Steps to get the API key (*client secret*)
  - Login to https://console.cloud.google.com
  - Select the DialogFlow project from the top left (after the Google Cloud logo) and use it in the code
  - Go to *API & Services > Credentials*
  - Then *Create Credentials* and choose *Service Account*
    - Pick your favorite service name
    - Grant access to *Dialogflow API Admin*
  - Open the newly created Service Account
  - Under *Keys*, choose *Add Key* and create a JSON key

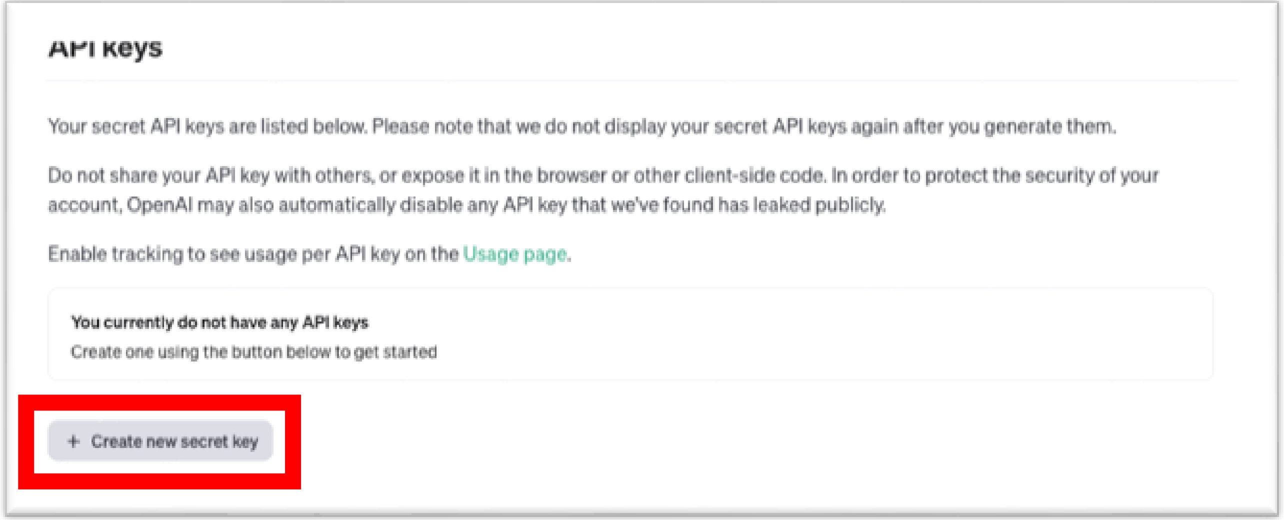
Movie App Prototype with ChatGPT

Steps:

- Set up the software environment:
  - Install OpenAI and Gradio libraries (via pip)
- Create a new developer account at https://platform.openai.com
  - or use your own, if any
- Get the OpenAI API Key – *see next slide*
- Build the chatbot using the ChatGPT APIs and personalize it
  - https://github.com/luigidr/openai-movies

Get the OpenAI API Key





API keys

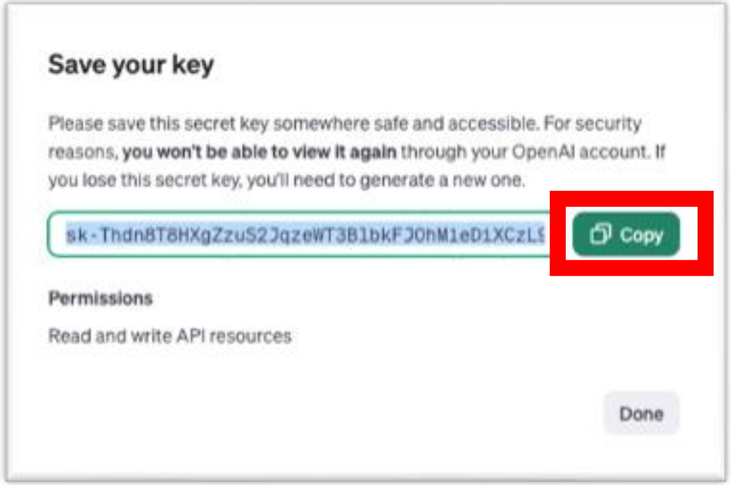
Your secret API keys are listed below. Please note that we do not display your secret API keys again after you generate them.

Do not share your API key with others, or expose it in the browser or other client-side code. In order to protect the security of your account, OpenAI may also automatically disable any API key that we've found has leaked publicly.

Enable tracking to see usage per API key on the Usage page.

You currently do not have any API keys

Create one using the button below to get started



Save your key

Please save this secret key somewhere safe and accessible. For security reasons, **you won't be able to view it again** through your OpenAI account. If you lose this secret key, you'll need to generate a new one.

sk-Thdn8T8HXgZzuS2JqzeWT3BlbkFJOhM1eD1XCzL

Permissions

Read and write API resources

References and More Information (in English)

- *Multimodal Interaction* – slides and video lectures:
  - https://elite.polito.it/files/courses/02JSKOV/2021/slide/10-multimodal.pdf
  - https://www.youtube.com/watch?v=AfVJiE1weGU
  - https://www.youtube.com/watch?v=wFP8g1AqDlQ
- *Voice User Interfaces* – slides and video lecture:
  - https://elite.polito.it/files/courses/02JSKOV/2019/slide/10-vui.pdf
  - https://youtu.be/bibKxK2Ok2U

References and More Information (in English)

- *Voice User Interfaces on the Web* – slides and video lectures:
  - https://elite.polito.it/files/courses/02JSKOV/2019/slide/11-vui-web.pdf
  - https://youtu.be/RiGeYFzZxuE
  - https://youtu.be/mHWt63jH-mI
  - https://youtu.be/YiIcJhpQJFk
  - https://youtu.be/VU5z-ALZJvo

License