ULB

Master in Computer Sciences

Academic year 2018 - 2019

Chat-bots playing social dilemma games: preparation to thesis (state of the art)

BAES Akira

Promotor : LENAERTS Tom Name Preparation to the Master Thesis

Contents

Chapter 1

Introduction

1.1 Background and objectives

In recent years, chat-bots evolved greatly. The technologies have been steadily refined, with some recent discoveries and products showing great promises. In addition to creating more convincingly "human" chat-bots, numerous new use-cases have been found. A lot of those include asking the chat-bot to perform task for us involving other humans, like planning a meeting or collecting feedback.

One interesting use-case would then be when there is conflict of interest with other humans, and how transferring the responsibility of the interaction to a chat-bot can change the way people behave.

One way to test this is trough social dilemma games (and specifically in the in the context of collective-risk dilemma), where participants have different interests but are socially compelled to cooperate and have to take some strategies. By inserting a chat-bot as stand-in for a player, we would expect to see change in the player's behavior.

The final purpose of the thesis is thus to create a chat-bot that can play social dilemma games in stead of a player, and use it in behavioral experiments. We will then observe if any change occur and if it can be modelised.

The first step is to create a framework for such chat-bot to function, and then implement it.

1.2 Structure

The first part and majority of this thesis preparation focuses on defining the state-of-the-art for chat-bots.

The second part highlights the possibilities born from using a chat-bot in a social dilemma game.

Notice:

After having written this pre-thesis preparation, I have a better idea of the scope of what is asked from me. I see now that I was too focused on the "chat-bot" part of the state of the art, and spent too much time reading about conversational chat-bots, by preference. Comparatively, I neglected the game theory, social dilemma and responsibility deferral side of the thesis preparation. I had overlooked the part where we would have to conduct behavioral experiments in the full thesis, which was source of some distress on my part.

Chapter 2

Chat-bots state of the art

2.0.1 Chat-bots overview

Chat-bots are a mainstay for a lot of modern task automation. While remaining software robots, they offer an interface to interact with humans more effectively trough simulating a conversation. They are present on every major social media platform. They interact via chat, or via voice. They can handle more requests at a fraction of the cost of a human and can be made available 24/7.

The concept started from the theoretical "machine intelligence" described in 1950 by Turing [Mac50] which describes a digital computer answering textual questions and natural conversation in an "imitation game" [Mac50], which later would become the Turing test, used in chat-bot competitions to define if a chat-bot can pass as human, being a driving force for conversational chat-bot research. [RW17]

Historically, the first conversational chat-bot was by MIT called ELIZA [Wei66], an early Natural Language Processing effort picking up keywords that made it talk like a psychotherapist. [Wei66]

Nowadays, chat-bots are a common commodity. For personal use like search assistant [Cha17], online purchases facilitator like Amazon Alexa's voice shop [Ama], entertainment bots like Earplay [RJ17], used as characters in video games like "Event[0]" [Ser16]), home domotics [Roc17], or "friendly" bots like entertainer and weather reminder Poncho [RL17]. Or in the enterprise for developer task automation trough Howdy [RE17], meeting scheduling with Amy and Andrew Ingram who will contact the person you want to have a meeting with in your stead [RK17], internal HR organisation answering to the question of employees and facilitating some administrative tasks [RA18], FaQ services generation like QnA [doc], surveys and feedback collection trough Wizu [Wiz]. New ranges of products are built around chat-bots everyday, like virtual concierge for hotels Ivy who takes care of customer check-outs, gives the wifi code and other repetitive actions [RS18], virtual English tutor Edwin [RAS18], virtual influencers [Chi19] or mental health helper and listener Woeboy [RD18].

This means innovation for chat-bots come from several directions.

2.0.2 Duality of chat-bots

There are roughly two facets to building a chat-bot:

- Conversation: chat-bots usually tries to pass as human, or at least facilitate the trading of information by acting as a human would expect [Ism19]. This humanness can be data-driven by training on large conversation datasets and generating content trough it [Exi] [Liu17], or more often it is written by a professional writer with a certain personality in mind [RW17]. Some bots are strictly conversational, while others can have conversation sub-routines or try to act their personality trough how they handle their tasks[RL17]. A lot of bots will refuse to interact with the user outside of their task. [RK17] [RS18]
- Problem solving: chat-bots are often used to solve a problem or provide a service more quickly and seamlessly than a different interface would. Problem-solving is often strictly following a decision tree or graph [RAS18], written by programmer or a planner. chat-bots can of course give information and give text answers, but they can also generate practical actions on request.[RE17]

Those goals usually overlap as customer service chat-bots try to look approachable and an entertaining chat-bots could be following a decision tree to try guide their conversation partner to a specific subject [RD18]. It is not a requirement though, as Conversation-only chat-bots exist, and "serious" chat-bots might have less of a personality and might be more on-task [RK17].

2.0.3 Complexity and scale

The complexity of chat-bots can be stratified in levels of sophistication [Nic18]

- Notification : Some people consider notifications and friendly reminders via social media as a form of chat-bot, as it is an automated message without human intervention.
- FAQ : The most basic chat-bot would be able to manage a simple conversation tree answering a static amount of on-topic questions. It is the case for most customer service chat-bots in the industry that can answer very simple and on-topic questions.
- Contextual : A more advanced chat-bot adapts its answers to the task. This can require more advanced natural language processing to detect which part of the task was changed.
- Personalized : More and more chat-bots are expected to adapts their answers to you, by remembering your personal informations.
- Autonomous organisation of assistants : at term, flock of AI could be managing several facets of a complex task.

Most of the industry's chat-bots are of FAQ level. They can look very impressive when they cover all possible questions in their defined domain by collapsing variations trough NLP (Natural Language Processing). There are some rare "contextual"-level chat-bots. We can see an early example of this with Google's Duplex, which can make appointments trough the phone with restaurants (even though 25% of the calls are actually handled by humans). [CM19] Most chat-bots don't have a good memory of you that is not an explicit information required to perform their task.

We can see that the complexity of a chat-bot can be linked both to the complexity of a task and the technology used.

2.0.4 Base concepts

There are different technologies at play.

- Conversation tree, conversation graphs, which is a way to structure the flow of the conversation and the content written by a writer, or the resolution of a complex task.[Lam18] This is usually custom-made. chat-bot scripting languages offer a structure that looks like a decision tree. AIML templates are a hierarchical tree-like structure. [AIM] ChatScript offers a similar structure with more general matching. [Wil11a]. More visual interfaces also exist. [Lea] A simple FAQ bot would only require a conversation tree based on the existing knowledge base to work. A very basic but efficient bot wouldn't even require the user to type anything, instead presenting them with button to push with pre-written answers.

- Natural Language Processing. Without it, the chat-bot can only process predefined sentences or commands. With it, it can match more varied speech patterns. chat-bot scripting languages like ChatScript offer NLP (Natural Language Processing) tools similar to regex matching, with packages of interchangeable synonyms and wording already available. [RW17] More advanced tools are available trough libraries like DialogFlow. [Dia] Any chat-bot that can accept freely typed user inputs must have some NLP to interpret it, even if it translates it to a simple command afterwards.

- Knowledge database. Often triplets, json entries or sentences, ontologies to feed the chat-bot useable knowledge or remember informations. There are different approaches. ChatScript comes with some pre-defined concepts in the form of patterns. "For representation, we use fact triples, subject-verb-object (SVO), fixed verb and ordering of fact." [RW17] Wordnet [Pri], a lexical database for english, can be used as an ontology for nouns. This can be used in Loebner competition to answer some of the general-knowledge questions. [RW17]

  One advanced example would be the supercomputer Watson which is able to answer general trivia questions. [Wha]It is using DeepQA, " a software architecture for deep content analysis and evidence-based reasoning " [16].

- Similarly, a chat-bot should also able to create new knowledge on the fly. A conversation chat-bot will have to learn things from its interlocutor by remembering informations stored as triples. Chatscript allows to create new patterns to store simple informations.

- Neural network with conversation data. A lot of chat-bots exist using this, but they often don't make convincing conversation partners, either speaking gibberish because of the randomness of the data they are fed (Cleverbot repeats what users write him [Cle]) or becoming increasingly focused on some topics because of a bias in the data (Microsoft's Tay was influenced by the tweet it was interacting with [Liu17], IBM's Watson's speech patterns were heavily influenced by visiting certain sites [Smi13]). Recently, there have been advances in text generation by OpenAI using "GPT-2 [...] a large transformer-based [[Vas+17]] language model with 1.5 billion parameters, trained on a dataset of 8 million web pages.", making it able to create full text based on the style of a sample. [Rad+19] [Rc19]. The full model however was not released to the public, "Due to concerns about large language models being used to generate deceptive, biased, or abusive language at scale" [Rc19]

2.0.5 Trained conversation bots vs Written conversation bots

Conversation bots can be classified in two categories: chat-bots trained on large amounts of data, with no defined personality or purpose, and chat-bots hand-crafted to fit a specific use case. [Wil11b]

Trained conversation bots

There are examples of conversation bots that are trained on user inputs interacting with the bot, as it is easier to collect, but can also be low quality.

- Cleverbot was directly trained on people conversing with Cleverbot. [Cle]
- TAY was trained on people tweeting it. An older version trained on Chinese social media was working very well. [Liu17]
- GPT2 was trained on websites featured on reddit (a link agregator) with positive voting from the community. [Ara19] This "general knowledge" is then refined to fit a subject or the style of a given sample of text.

Trained AI require a big amount of data, so sorting this data and using it efficiently is one of the challenges. If the training data is very chaotic, the bot itself will be poorly coherent. As seen with GPT2, by training on data that has been trough some selection, the quality of the data improves. It also highlights that the efficacy of the language model used is also important.

Written conversation bots

On the other end, there are conversation bots for which every answer was written by a writer/programmer.

They usually use pattern matching as NLP to flow from one answer to another. Scripting the whole tree usually require developer input for every structure.

For example, a query for weather would look like:

[query] [meteo, weather, sky]

The chat-bot then has to match "what's the weather?", "tell me the meteo" (as [query] would have been defined earlier as every query styles) and output:

task, [present] weather [info]

Understanding what a query is, or synonym for weather, is part of Natural Language Processing. In ChatScript, it is handled by other patterns that compress synonyms and concepts down to their canonical lemma. [RW17] A lot of it is written by hand to match every possible combination. Such matching patterns can then be reused in different context. It is possible to process wide databases with such rules and create more ontologies.

To this day, it's mostly written chat-bots that are competing in Loebner Turing tests, where they have to fool human judges into thinking that they are more human than a competiting human conversationalist. This is due to their capacity to express complex stories in volley when the chat-bot is in control of the conversation. [RW17]

2.0.6 Comparison AIML/Chatscript

When selecting for open-source technology for writing a mathinc tree chat-bot, the leading technology is AIML. An alternative is ChatScript, which claims to have better expressivity. [Wil11b] [Wil14] Another possibility is Riverscript, which aims to simplify AIML. [Pet]

Based on a review comparing AIML and ChatScript, here are the differences : [Ars+17]

AIML has easier dialog modelling, simple but wordy (xml) language, and is lightweight (can fit into a mobile application). AIML is also used in Pandorabox, which simplifies greatly the hosting and deployment of the bot on several platforms.

ChatScript has more powerful but complex tools for Natural Language Processing, and built-in ontologies that makes memory-intensive.

For a lightweight application, AIML or Riverscript seem very appropriate. To have access to in-script NLP tools and ontologies, or create more convincing conversational chat-bots, ChatScript might be worth the effort.

2.0.7 Interfacing

The text chat-bot AI can then interface with any program that uses text as input and output. Notable example : social web platforms like Facebook, Reddit or Twitter have tools and services to create chat-bots easily. Communication apps like Telegram, Discord... can also have chat-bots. You can self-host a chat-bot. Virtual assistants like Alexa, Google Assistant etc. show example of using text-to-voice and voice-to-text to interface with a chat-bot. Chat applications have sometimes chat-bots. Very simple chat-bots in the wild can be seen serving ads or scams to their conversation partner. Some MMO games have chat-bots that administrate some segment of the game. They usually take and answer to simple commands, or organise games and events for players.

Customer help line chats often have chat-bots trying to guide customers into their service tree. The trees are often simple and so the options are often made explicit to the customer, reducing the illusion of chatting and more like browsing a menu.

Chapter 3

Chatbot playing social dilemma games

3.1 Thesis statement

Our final purpose is to create a chatbot to play social dilemma games. In particular, we are interested in how delegating the actions to an agent (here a chatbot) would affect the behavior of the human player, and in particular, in collective-risk dilemma. At this end, we will need to conduct behavioral experiments in this context, and then finally create a model based on our observations.

As Tom Lenaerts puts it : "Game theory offers an excellent framework to study situations of conflixt and cooperation among intelligent decision-makers. It has helped researchers understand a range of social situations that go from why cooperation may emerge in a population of selfish individual to the emergenge of norms in society. However, current developments in artificial intelligence indicate that humans might increasingly delegate their decision power into artificial agents with consequences still poorly studied. Additionally, how will human interact with such agent and how this interaction would affect the overall behaviour of the system ? This scenario motivates the present master thesis. We wish to implement a platform in which chatbots, i.e. artificial agents that can interact with humans in natural langage, may serve as an interface between humans and other artificial agent in a game theoretical context."

Indeed, delegating a task instead of doing it yourself can change your perception of the situation.

3.2 Social dilemma background

Social dilemma game simulate a situation where there arise a friction between the choice of acting selfish and cooperating, due to a contradiction in the final reward in the payoff matrix [Len18] where acting selfish (defecting) has a lower/negative reward if everyone acts selfish, but the highest reward if others cooperate (betrayal). In repeated social dilemma games, more advanced strategies will manifest based on reputation built on the result past interactions. [PSC06; SSP18] Players might also change their strategy

due to the presence of social control of reputation. [San18] This change is heightened if the player feels observed. [Bat+13] By introducing a neutral chatbot, we could be reducing the social control aspect of the experiment by distancing the player from other players by discharging some of the responsibility. Similar research include delegating task management to a chatbot. [TMC18] The purpose of the full thesis would be to develop a framework for human-agent interactions trough the chatbot. In particular, we are interested in repeated social dilemma games, with focus mainly on collective-risk dilemma, in particular the collective social risk dilemma experiment introduced by Milinski and co [Mil+08], for which there is already a framework available. Once the framework is working, we would need to conduct behavioral experiments to study the effect of delegating actions to chatbots, and build a model to understand it.

3.2.1 Expanding the scope

We can balance anonymity and social proximity by making the bot's speech and personnality less or more human, less or more involved in the game, or by adding eyes on the interface to increase the feeling of social control. [Bat+13] Display of verbal and nonverbal emotional cues can be driven by a model of their interpersonnal effect based on existing research. [Mel+11]

3.3 Practical framework for the chatbot

For our purposes, a hybrid model based on chat scripting langages and basic game theory seems to be the most adapted. The chatbot would not be focused on furthering a conversation. The chatbot would have its own expertise of the game and present suggestions to the user (for example, based on timing [Hil+13] or using known solving methods [Che+14]), either when prompted by the user, or when certain conditions are met in the game It is to discuss wether the bot should present the state of the game, or if this is better presented as a separate interface. The bot would receive and understand instructions (defect, cooperate) from the player at specific times, and pass them on to the game engine. To this effect, machine-learning chatbots seem inappropriate. The most effective would be a hand-scripted chatbot with a simple decision tree as driving logic. The amount of Natural Language Processing would be very limited, enough to understand game-specific commands and wordings. It is to discuss if NLP would be of any use, as depending on how the interface is built, simple text-buttons could be as efficient. If voice commands are used, NLP would be useful.

Conclusions

The conclusions are to be written with care, because it will be sometimes the part that could convince a potential reader to read the whole document.

Bibliography

[Mac50] Computing Machinery. "Computing machinery and intelligence-AM Turing". In: *Mind* 59.236 (1950), p. 433. URL: https://www.csee.umbc.edu/courses/471/papers/turing.pdf.

[Wei66] Joseph Weizenbaum. "ELIZA—a computer program for the study of natural language communication between man and machine". In: *Communications of the ACM* 9.1 (1966), pp. 36–45. URL: https://s3.amazonaws.com/academia.edu.documents/31085335/ElizaScript.pdf.

[PSC06] Jorge M Pacheco, Francisco C Santos, and Fabio AC C Chalub. "Stern-judging: A simple, successful norm which promotes cooperation under indirect reciprocity". In: *PLoS computational biology* 2.12 (2006), e178. URL: https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.0020178.

[Mil+08] Manfred Milinski et al. "The collective-risk social dilemma and the prevention of simulated dangerous climate change". In: *Proceedings of the National Academy of Sciences* 105.7 (2008), pp. 2291–2294. URL: https://www.pnas.org/content/pnas/105/7/2291.full.pdf.

[Mel+11] Celso M de Melo et al. "A computer model of the interpersonal effect of emotion displayed in a social dilemma". In: *International Conference on Affective Computing and Intelligent Interaction*. Springer. 2011, pp. 67–76.

[Wil11a] Bruce Wilcox. *Pattern Matching for Natural Language Applications - ChatScript*. Feb. 2011. URL: https://github.com/ChatScript/ChatScript/blob/master/WIKI/PAPERS/Paper-Pattern-Matching-for-Natural-Language-Applications.md (visited on 05/26/2019).

[Wil11b] Bruce Wilcox. *Suzette, the Most Human Computer*. 2011. URL: https://www.gamasutra.com/blogs/BruceWilcox/20110622/7840/Suzette_the_Most_Human_Computer.php (visited on 05/26/2019).

[Bat+13] Melissa Bateson et al. "Do images of 'watching eyes' induce behaviour that is more pro-social or more normative? A field experiment on littering". In: *PloS one* 8.12 (2013), e82055. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3855385/.

[Hil+13] Christian Hilbe et al. "The evolution of strategic timing in collective-risk dilemmas". In: *PloS one* 8.6 (2013), e66490. URL: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0066490.

[Smi13] Dave Smith. *IBM's Watson Gets A 'Swear Filter' After Learning The Urban Dictionary*. Jan. 2013. URL: https://www.ibtimes.com/ibms-watson-gets-swear-filter-after-learning-urban-dictionary-1007734.

[Che+14] Xiaojie Chen et al. "Solving the collective-risk social dilemma with risky assets in well-mixed and structured populations". In: *Physical Review E* 90.5 (2014), p. 052823. URL: https://arxiv.org/abs/1411.3708.

[Wil14] Bruce Wilcox. *Winning the Loebner*. 2014. URL: https://gamasutra.com/blogs/BruceWilcox/20141020/228091/Winning_the_Loebners.php (visited on 05/26/2019).

[Ser16] Thomas Faust interviewing Sergey Mohov. *QA: Ocelot Society on building Event[0] around an AI chatbot*. Nov. 2016. URL: https://www.gamasutra.com/view/news/285902/QA_Ocelot_Society_on_building_Event0_around_an_AI_chatbot.php (visited on 05/26/2019).

[16] *The DeepQA Research Team : DeepQA*. July 2016. URL: https://researcher.watson.ibm.com/researcher/view_group_subpage.php?id=2159.

[Ars+17] Sasa Arsovski et al. "ANALYSIS OF THE CHATBOT OPEN SOURCE LANGUAGES AIML AND CHATSCRIPT: A Review". In: (2017). URL: https://www.researchgate.net/publication/323279398.

[Cha17] Sze Tho ChangSheng. *Chatbots Will Change the Way We Do Search*. Mar. 2017. URL: https://chatbotsmagazine.com/chatbots-will-change-the-way-do-search-561a257f4d90 (visited on 05/26/2019).

[Liu17] Yuxi Liu. *The Accountability of AI - Case Study: Microsoft's Tay Experiment*. Jan. 2017. URL: https://chatbotslife.com/the-accountability-of-ai-case-study-microsofts-tay-experiment-ad577015181f (visited on 05/26/2019).

[RE17] Arun Rao and Soelzer Eric. *Howdy and Botkit, An Interview with Eric Soelzer*. Apr. 2017. URL: https://chatbotsmagazine.com/howdy-and-botkit-an-interview-with-eric-soelzer-2051b88c33d1 (visited on 05/26/2019).

[RJ17] Arun Rao and Myers Jon. *Earplay: What Chatbots can Learn from Interactive Voice Games*. June 2017. URL: https://chatbotsmagazine.com/earplay-what-chatbots-can-learn-from-interactive-voice-games-bd49d9148fd6 (visited on 05/26/2019).

[RK17] Arun Rao and Diane Kim. *Amy and Andrew Ingram - Your meeting scheduler AI assistants from X.AI: An Interview with Diane Kim, Interaction Designer*. Dec. 2017. URL: https://chatbotsmagazine.com/amy-and-andrew-ingram-your-ai-assistants-from-x-ai-d350f5f58e43 (visited on 05/26/2019).

[RL17] Arun Rao and Greg Leuch. *Poncho the Weather Cat, An Interview with Greg Leuch*. Mar. 2017. URL: https://chatbotsmagazine.com/poncho-the-weather-cat-an-interview-with-greg-leuch-908cfd827aba (visited on 05/26/2019).

[RW17] Arun Rao and Bruce Wilcox. *Rose in the Loebner Chatbot Competition: An Interview with Bruce Wilcox of Brillig Understanding*. Jan. 2017. URL: https://chatbotsmagazine.com/rose-in-the-loebner-chatbot-competition-an-interview-with-bruce-wilcox-eac0a8b61647 (visited on 05/26/2019).

[Roc17] Ricardo Jorge da Rocha Loureiro. "Chatbots for Domotics - Interface Conversacional para domótica". In: (2017).

[Vas+17] Ashish Vaswani et al. "Attention Is All You Need". In: *CoRR* abs/1706.03762 (2017). arXiv: 1706.03762. URL: http://arxiv.org/abs/1706.03762.

[Lam18] Martin Lambert. *Chatbot Decision Trees*. Apr. 2018. URL: https://chatbotsmagazine.com/chatbot-decision-trees-a42ed8b8cf32 (visited on 05/26/2019).

[Len18] Tom Lenaerts. *Learning Dynamics : part 1 : Game Theory Basics*. University Lecture. 2018.

[Nic18] Alan Nichol. *The next generation of AI assistants in enterprise*. Sept. 2018. URL: https://www.oreilly.com/ideas/the-next-generation-of-ai-assistants-in-enterprise (visited on 05/26/2019).

[RA18] Arun Rao and Jain Adit. *Leena - Automating the HR Helpdesk (Adit Jain)*. Oct. 2018. URL: https://chatbotsmagazine.com/leena-automating-the-hr-helpdesk-adit-jain-9c0d3a6660ae (visited on 05/26/2019).

[RAS18] Arun Rao, Dmitry Alekseev, and Dmitry Stavisky. *Edwin.AI is your English as a Foreign Language (EFL) Tutor (Dmitry Alekseev and Dmitry Stavisky)*. July 2018. URL: https://chatbotsmagazine.com/edwin-ai-is-your-english-as-a-foreign-language-efl-tutor-dmitry-alekseev-and-dmitry-stavisky-40439d37cf3d (visited on 05/26/2019).

[RD18] Arun Rao and Alison Darcy. *Woebot- Your AI Cognitive Behavioral Therapist: An Interview with Alison Darcy*. Jan. 2018. URL: https://chatbotsmagazine.com/woebot-your-ai-cognitive-behavioral-therapist-an-interview-with-alison-darcy-b69ac238af45 (visited on 05/26/2019).

[RS18] Arun Rao and Raj Singh. *Ivy is a 24-hour virtual concierge service that smooths the stay of guests at hotels (Raj Singh)*. July 2018. URL: https://chatbotsmagazine.com/ivy-is-a-a-24-hour-virtual-concierge-service-that-smooths-the-stay-of-guests-at-hotels-raj-singh-12ceacd5cd7b (visited on 05/26/2019).

[SSP18] Fernando P Santos, Francisco C Santos, and Jorge M Pacheco. "Social norm complexity and past reputations in the evolution of cooperation". In: *Nature* 555.7695 (2018), p. 242.

[San18] Francisco C. Santos. *Computer Science Seminar: Social norm complexity and human cooperation*. University Seminar. 2018.

[TMC18] Carlos Toxtli, Andrés Monroy-Hernández, and Justin Cranshaw. "Understanding chatbot-mediated task management". In: *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM. 2018, p. 58. URL: https://arxiv.org/pdf/1802.03109.pdf.

[Ara19] Ajay Uppili Arasanipalai. *GPT-2: How to Build "The AI That's Too Dangerous to Release"*. May 2019. URL: https://blog.floydhub.com/gpt2/ (visited on 05/26/2019).

[CM19] Brian X. Chen and Cade Metz. *Google's Duplex Uses A.I. to Mimic Humans (Sometimes)*. May 2019. URL: https://www.nytimes.com/2019/05/22/technology/personaltech/ai-google-duplex.html (visited on 05/26/2019).

[Chi19] Aaron Chichioco. *Virtual Influencers: The Significance of Influencer Chatbots to Your Brand Strategy*. May 2019. URL: https://chatbotsmagazine.com/virtual-influencers-the-significance-of-influencer-chatbots-to-your-brand-strategy-f6206c48adea (visited on 05/26/2019).

[Ism19] Nick Ismail. *The history of the chatbot: Where it was and where it's going*. Feb. 2019. URL: https://www.information-age.com/history-of-the-chatbot-123479024/ (visited on 05/26/2019).

[Rc19] Alec Radford and &co. *Better Language Models and Their Implications*. Feb. 2019. URL: https://openai.com/blog/better-language-models/ (visited on 05/26/2019).

[Rad+19] Alec Radford et al. "Language models are unsupervised multitask learners". In: *OpenAI Blog* 1 (2019), p. 8. URL: https://d4mucfpksywv.cloudfront.net/better-language-models/language_models_are_unsupervised_multitask_learners.pdf.

[AIM] AIML. *AIML Docs*. URL: http://www.aiml.foundation/doc.html (visited on 05/26/2019).

[Ama] Amazon. *Alexa Voice Shopping: How it Works*. URL: https://www.amazon.com/b?ie=UTF8%5C&node=16924225011 (visited on 05/26/2019).

[Cle] Cleverbot site. *Cleverbot*. URL: https://www.cleverbot.com/ (visited on 05/26/2019).

[Dia] Google Dialogflow. *Dialogflow*. URL: https://dialogflow.com/.

[doc] QnA Bot documentation. *QnA bot - Azure Bot Service - QnA Maker - Azure Cognitive Services*. URL: https://docs.microsoft.com/en-us/azure/cognitive-services/qnamaker/tutorials/create-qna-bot (visited on 05/26/2019).

[Exi] Existor. *Cleverbot Data for Machine Learning*. URL: https://www.existor.com/products/cleverbot-data-for-machine-learning/ (visited on 05/26/2019).

[Lea] LeadFlip. *LeadFlip — Flip visitors into actionable leads*. URL: https://panel.leadflip.ai/features.

[Pet] Noah Petherbridge. *RiveScript vs. AIML*. URL: https://www.rivescript.com/compare/aiml (visited on 05/26/2019).

[Pri] Princeton. *WordNet - A Lexical Database for English*. URL: https://wordnet.princeton.edu/ (visited on 05/26/2019).

[Wha] WhatIs.com. *What is IBM Watson supercomputer? - Definition from WhatIs.com*. URL: https://searchenterpriseai.techtarget.com/definition/IBM-Watson-supercomputer (visited on 05/26/2019).

[Wiz] Wizu. *Conversational Surveys Vs Traditional Surveys*. URL: https://www.wizu.com/customer-case-studies/conversational-surveys-vs-traditional-surveys/ (visited on 05/26/2019).