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Using artificial intelligence for the benefit of the circular economy

Ionuț-Alexandru CÎMPEANU*
Bucharest University of Economic Studies, Bucharest, Romania
**Corresponding author, ionut.cimpeanu@csie.ase.ro*

Denis-Alexandru DRAGOMIR
Bucharest University of Economic Studies, Bucharest, Romania
denis.alexandru97@gmail.com

Răzvan Daniel ZOTA
Bucharest University of Economic Studies, Bucharest, Romania
zota@ase.ro

Abstract. Human intelligence has no limits and constantly impresses with innovative solutions that increase in complexity, applicability, and efficiency. With the advancement of technology and the passage of time, there was a need to move from the linear economic model, which involved the implementation of the "take-make-waste" process and which causes negative effects on the environment and society, to the circular model, which promises a much regenerative. Artificial intelligence is beginning to take shape day by day in more and more branches of activity. In this article, we will present how artificial intelligence helps the field of the circular economy. Thus, we will present two chatbot solutions (A.I.R-e and Iio) that are already implemented in the field of circular economy and have the role of helping the human population. A.I.R-e uses both visual object recognition technology, helping to separate waste according to its nature, as well as auditory and language, to provide information about collection centers and answer user questions. It was implemented by TheCircularLab platform and is used in Logroño (Spain). The second chatbot model is called Iio and is used in Yokohama, Japan. It was developed by NTT Docomo and serves to answer users' questions about sorting waste and where it should be taken for recycling. The chatbot knows how to give instructions on the categories of waste sorting, to guide the user to the nearest landfill, but also to answer and give answers that will impress you if a user types a word that does not have to do with waste recycling.

Keywords: Circular Economy, Artificial Intelligence, chatbots, software, recycling

Introduction

In recent years, there has been a worldwide focus on research of all kinds on climate change and environmental challenges. In this context, more and more research is being done on the field of circular economy, which can be one of the answers to these challenges. The circular economy is already a field in full development, with many branches that include research in the fields of economics, metallurgy, chemistry, biotechnology, Information Technology and Communications (ITC), etc.

Also, there are today for the circular economy a series of models or frameworks of multiple types "R": 3R, 4R, 6R, 9R (Demestichas & Daskalakis, 2020), where "R" can represent Reduction, Reuse, Recycling, Recovery, Redesign, Remanufacturing, Repair, Rethink or Redo. Regardless of the chosen framework, how the circular economy is helped to develop is important.

Among these ways, we identify the very important role of the ITC field, which, through its applications, can contribute to better management and development of the circular economy. The ITC domain can contribute to the advancement of the circular economy with a whole series of

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subdomains, such as Communications, Computing Technologies, Data Science, Software and Simulation Technologies, Artificial Intelligence (AI) Algorithms, etc.

Of all the possible applications of the ITC domain in the circular economy, we have focused on how developments in the field of AI can positively influence the development of the circular economy. Given that there are a multitude of AI technologies (big data analysis, fuzzy logic, heuristic algorithms, machine learning, recommendation systems, semantic processes, etc.) that may have applicability in promoting circular economy, we have focused on solutions that use chatbots for the benefit of the circular economy.

Starting from the definition of chatbots as software programs that can chat with people using AI, we have identified and analyzed two very interesting chatbot applications that help the circular economy domain. Given the high potential of such solutions, in the future, in our turn, we intend to build chatbot solutions with applicability within the circular economy.

In this article, we will first present the characteristics of a chatbot used in the city of Yokohama, Japan, to clarify the issues related to the selective collection of waste by the population. This chatbot is based on Mictionary, which is a database on waste selection in the city of Yokohama, and Repl-AI, a chatbot technology developed by the famous Japanese telecommunications company NTT Docomo.

Our second example is represented by a chatbot called AIRE (Asistente Inteligente de Reciclaje) developed by TheCircularLab (TCL), which is the first innovation center for circular economy created in Europe. TheCircularLab was born in May 2017 in the city of Logroño (Spain) and is the mainstay of the Ecoembes organization, aiming to promote the best directions for innovation in the field of packaging and their subsequent recycling.

Literature review

According to the specialty literature, a circular economy is no more than a structure that is occupied with integrating and enforcing four main laws regarding resources that go through different cycles, having in mind two main ideas based on which it operates: improving the efficiency and the reusability of the constituent components and materials and trying to put an end to the misusage of the former. The four main principles are, as follows: **repair**, **reuse**, **recycle**, **remanufacture**.

Various definitions of the concept can be found in many documents spread across, but the one that shines comes from F. Sariatli, who, in his work entitled 'Linear Economy Versus Circular Economy' (Sariatli, 2017) views the EC as 'An economy that focuses primarily on the industry in which material flows and streams must not contain contaminated behavior and must be circulating with a relatively high speed, entering a sensible area (such as the biosphere) only if they are represented by nutrients'. In other words, an industrial economy with regenerative characteristics by pure and sole intention.

W. R. Stahel, in his work, "The circular economy" (Stahel, 2016), specifies that, as a whole, this notion operates on four main levels:

1. Policies – markets need incentives and regulations that sustain circular development
2. Networks – customers (or, as he calls them, 'final users') and companies must be strongly linked through them.
3. Companies – private and public value creation must be obtained through the adoption of new circular business models
4. Products, the lowest and the most granular level of action, states that the main actors of the system must be designed according to their wanted environment: clean, and in a reusable fashion.

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To make the transition between EC's predecessor (the linear model) and the EC itself, a series of measures must be taken into consideration. Changes that do not only mean the mitigation of actual effects. Instead, they should be supported by long-term resilience stimulation and opportunities generation. To facilitate this process, one specific tool that can be used is represented by artificial intelligence (AI). As said in the document entitled "Leveraging artificial intelligence to advance Circular Economy" – Mission C and Fountech Solutions, "AI can be loosely defined as a program or software that is designed and built specifically to mimic human behavior. Amongst others, this means processes such as learning, reasoning, problem-solving and so on." (Foundtech.Solutions, 2020)

That, combined with the fact that digitalization can be used to enhance business processes, can make the former one of the most important drivers of CE. Well, AI surely has a large role to play there, as, by 2030, it is expected that it can help unlock a value of one hundred twenty-seven million USD per year in the food department alone.

Some examples where AI can be used to enable circular practices in companies and organizations are, as follows:

- Clustering – creating groups of the various data points retrieved from a single piece of information or data
- Timeseries analysis – describing how a variable evolves. To give a concrete example, we can monitor the evolution of resource consumption in an arbitrarily selected domain over one or one and a half years.
- Object detection – finding if a particular object is in an image or not. For example, we can use this to detect if a specific food container has the necessary attributes but in a specific category of waste materials – plastic, textile, and so on.
- Chatbots – the subject addressed in this paper. They represent programs created by humans to automatically interact with other humans. They can communicate, address questions, respond, give useful information, and learn as they go using complex machine-learning algorithms.
- Entity recognition – take sin digital text and produces relevant data which can be used in specific domains. For example, we can use this technique to find all the nutritional values of a specific product.
- Summarization – taking a vast input of information and retrieving only the key points from there
- Natural language understanding: converting words into quantifiable objects

Methodology

The research procedure and methods chosen are based on:

- chatbots made and implemented in the circular economy;
- online platforms used in the circular economy in our country / at European / global level were observed, researched, analyzed: multiple existing options for users, originality of solutions integrated into the platform, options for starting international projects individually or through collaboration, translation of the language of communication from the platform from several foreign languages to a multitude of foreign languages, news in the field exemplified in articles made by specialists;
- how the proposed objectives in this sector have been achieved;

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- folding these solutions to what we, as research partners, want to achieve at the end of the doctorate: an online platform / a mobile application in the circular economy and a chatbot implemented in the field of smart/sustainable cities.

In this sense, our research activity has focused on qualitative research and research through mixed methods (Muntean, 2018).

The methods we used in qualitative research were:

a. case study;
b. thematic study of documents;
c. participant observation;
d. focus on the group.

The case study consisted of documents on the Internet about different online platforms used in the circular economy, videos and courses with functionalities of these platforms, reading articles about online platforms in the circular economy, but also about artificial intelligence solutions implemented in the platform, impact implementation and use of chatbots in the circular economy, study of magazines and other specialized publications in the field, online meetings/meetings with supervising professors from the Doctoral School of Economics at ASE Bucharest in which these topics were discussed, as well as guidance towards the personalized development of the IT solutions chosen in the doctoral activity: the online platform / mobile application in the circular economy and a chatbot implemented in the field of sustainable smart cities.

The thematic study of the documents consisted of the study of articles, specialized magazines, videos with specific content, courses on using the options in the platforms, courses with codes for developing a chatbot and implementing various options. This stage was continued by sorting the documents found according to the artificial intelligence solutions implemented in the platforms and the complexity of the online platform / the multitude of platform options / the creativity and originality of the IT solutions.

The participant observation consisted in the online meetings with the guiding professors from the Doctoral School of Economics at ASE Bucharest, face-to-face meetings with the research doctoral partner but also with senior colleagues in the IT field with whom I exchanged ideas, opinions and from whom we have taken over valuable information for the research activity and for the development of the IT solutions we are working on.

The focus of the group consisted of collaboration and teamwork in achieving the proposed objectives, mutual support, encouragement, finding original and creative solutions, paying attention to the research topic, and the approach of each member of the group.

Mixed method research involves combining both forms of qualitative and quantitative research (Harpaila, 2016). As mixed method strategies, we applied the sequential mixed method procedures. These procedures involve an explanatory sequential design consisting of:

- Collection and analysis of quantitative data on on-line platforms used in the circular economy in the first phase of research, followed by collection and analysis of qualitative data in the second phase, which was built on the results of the first phase of research. In the second phase of research, we chose the online platforms used in the circular economy according to the criterion of artificial intelligence implemented as a business solution in this branch, in different countries;

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- weak point - time duration for data collection, analysis, comparison;
- strengths – the simplicity of this design, the originality of the integrated IT solutions implemented (the chatbot offers useful suggestions on where to place various types of packaging sorted using voice call, text message, image recognition, on-line platforms with a multitude of options for users in various languages).

Results and discussions

A.I.R-e, a virtual recycling assistant designed and developed by TheCircularLab

In the last 150 or more years, the human species has performed a considerable amount of work to develop an economy industrial by nature, that has resulted in benefits and affluence never seen before. However, we designed products and services for the sole purpose of being an adjuvant for the economic system, the latter being relatively complex and hard to grasp.

Nowadays, the ambition has scaled in such a manner that new ways to depict those things must consider the possibility of complete inclusion and exhaustive comprehension of the sophisticated structure in a cause. New technologies, which speed up the processes and the iterative cycles of designing, developing, maintaining, and getting feedback are needed to redesign crucial characteristics of the economy, without being overburdened by social, cultural, and environmental collisions. More than that, the need for rapid change to bring sustainability to the table and support fast intrinsic extension can and will be another important factor in the evolution requirement.

Thus, new tools have been invented to make sure that the only barricades that we meet along the way are just material (the world not having infinite resources for us to work with) and imaginative (we possess all we need to build something, but what?). One such tool is represented by **Artificial Intelligence** (AI), which can help to accelerate the transition from a linear model to a circular one, from a static point of view doing a more dynamic and versatile one. In other words, we can substitute the old "take-produce-waste" concept with one which is, by nature, more regenerative, and which aims at separating the process of material consumption from the inner growth of the system.

The underlying question that arises is the following: "How can artificial intelligence help with the transition to a circular-based economic system?". Well, numerous studies conducted for that matter have shown that AI is a great mechanism that helps deal with complexity more effectively and better understand the enormous amount of data. To be more precise, there are three main ways of action to enable circular economy enhancement and innovation:

- Develop circular modules, products, components, and materials – through repetitive machine learning processes that support by default rapid testing
- Predictive maintenance, smart management, and the usage of historical data – working with circular business models, in other words
- Circular infrastructure optimization – required to close the loop on materials and products that will be reused among different cycles in the system

One application of artificial intelligence is represented by the chatbot. Chatbots, also known as conversational agents, are automated entities that are meant and can be used to interact and communicate with humans. They help in providing useful information regarding a subject and in doing various things depending on the functionalities they have at their disposal. One of such functionality that may be represented by the entity recognition can be used to distinguish between different kinds of waste material, thus helping to sort and recycle them more efficiently and cleanly than before.

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A very good and indicative example of this is the chatbot designed and developed by **TheCircularLab** in collaboration with **Accenture**, named A.I.R-e – **Asistente Inteligente de Reciclaje** (The intelligent recycling assistant, see below). Its main strengths are that it uses a different type of recognition (image, as we have already seen, voice and text) and helps users by answering a different question about the circular model and recycling in general. It is the result of numerous people's efforts with the central objectives of raising public awareness and mass information, implementing the concepts of smart waste and ecodesign, and trying to enforce the growth of entrepreneurship. Using the technologies mentioned above, the bot helps by identifying the type of material a package is made of, facilitating the process of recycling other assortments of waste too, such as wood – furniture, textiles, and so on. (Ecoembes, 2018)



Figure 1. Say hello to A.I.R-e!

Source: https://www.thecircularlab.com.

According to the official product description, although many citizens are aware of the importance that recycling has and its numerous benefits for the environment, it is very common among them to doubt some of the key factors of this initiative. There are some products, processed foods, and containers that make them wonder what material the former is made of and what they can do to help. Using this reasoning, **Ecoembes**, with the help of **TheCircularLab**, has developed this platform. You can ask it where to throw a piece of paper or where to find a clean spot, it will answer with the latest information available. One relevant example of this behavior will be the following question: "*Where to throw the coffee capsules?"* and the answer can be something like this: "*The coffee capsules have to go to the gray container or the clean point." In any case, it seems that in your area there are some collection centers organized by their brand and popularity. I can give you the names and the basic description, but why not go to their website to find which of them is closest to you? '* . (Ecoembes, 2018)

What makes this bot shine is that, in addition to the usual voice and text recognition which makes him a very good informative tool, it also has image recognition. Roughly put, image or object recognition is the process of identifying things of interest within an image, as well as the category they belong to. This opens numerous and various opportunities to help reduce the waste of resources and to try to reintroduce consumed materials back into the economy by using smart processes and practices. Using this and the self-learning techniques that it already possesses, it will become more autonomous over time and will make better decisions to accelerate its development.

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As for the technologies, it uses Google DialogFlow for the native language, Google Text-to-Speech for the voice, and a combination of two platforms for the visual aspect (Google Vision and Amazon Rekognition).

In terms of availability, the application is already implemented on Apple Store and Google Play, Facebook Messenger, Twitter, Alexa. Sadly, no English language support is available yet (only Spanish, Catalan, Galician and Basque for now.)

Chatbot Iio in Yokohama, Japan, implemented in the circular economy

In Japan, the government pays more attention to recycling by informing the public about:

- what it means to collect rubbish and recycle it;
- the environmental benefits of these actions;
- detailed rules on garbage selection;
- depositing it in containers specially designed for different categories of recycling objects;
- sanctioning citizens/companies that violate these rules;
- monitoring the observance of the collection and sorting rules, as well as the deposit of garbage in the specially arranged spaces by setting up rooms in different places.

To make various human activities more efficient, the mayors of some Japanese cities understood the importance and need for the use of artificial intelligence. Thus, in the circular economy, where the way to dispose of garbage depends on the town hall, the rules and regulations adopted by local councils, and which citizens must follow to have a clean, less polluted city and reuse much of the waste. gathered by the population, intelligent IT solutions have been developed that promote these activities and help to achieve recycling. Citizens must follow detailed rules on how to properly select and dispose of garbage in an attempt to promote the three core activities in the circular economy, namely the three Rs:

a. Discount
b. Reuse
c. Recycling

An example of this is the city of Yokohama. The city's Recycling and Environment Office uses a chatbot that can answer questions from citizens about how to recycle garbage, how and where to store various recyclables, and how to separate garbage according to the categories of recyclables that are recycled. gather, what objects can't be burned, where they can bring old appliances and appliances, as well as large objects that people no longer use (Aoki, 2019). With this chatbot, the mayor asks people to sort the trash according to the category to which it belongs:

- combustible waste;
- used batteries;
- spray cans used;
- incombustible garbage;
- plastic containers and packaging;
- cardboard or plastic boxes;
- bottles, jars
- PETs
- small metal articles;
- used paper
- used cloth or other textile materials;
- old appliances;
- oversized garbage.

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The recycling rules in the city of Yokohama require citizens to dispose of a certain category of waste before 8 am in specially designated places, on a certain day of the week dedicated to this action, following that on the other days of the week, the recycling activity will continue, on days, with the other types of recyclable objects.

The Iio Chatbot can tell every citizen it talks about how to dispose of all kinds of garbage. Thus, in a conversation between a chatbot and a citizen, the citizen tells Iio that he wants to throw a frying pan. Iio's first answer is, “If you want to throw away a metal pan, it should be sorted like a metal item. But if the pan is longer than 30 cm (excluding the handle), it should be thrown away as excess garbage”. Iio's second answer to the same question of the citizen is: "If you want to throw a ceramic pan, it should be sorted into small metal items." Chatio Iio adds in the last answer to the citizen: "By the way, metals are recycled in the category of building materials" (Aoki, 2020).

It can be difficult for the citizen to sort the garbage, to determine in which category each item he takes to the garbage falls. The Iio chatbot comes to the aid of the citizen by clarifying this information. All a chatbot needs to do is enter the name of the trash item in a written or verbal message to the Iio chatbot, which will tell the person what to do with the trash item. The Iio chatbot even offers tips on things that people throw away, but you need to keep they in mind when these items are dangerous, such as a lighter. Thus, when the Iio chatbot notices that a person wants to throw a lighter in the trash, he says, "Make sure there is no gas residue in the lighter because it can cause a fire at the collection point!". (Sea, 2017)

The Iio chatbot includes a database on garbage sorting in Yokohama and Repl-AI, a chatbot technology from the telecommunications company NTT Docomo Japan. The chatbot is being developed to raise awareness of recycling and to spread knowledge about garbage sorting. The chatbot's knowledge base includes keywords in the field of recycling, reuse, and sorting of garbage, as well as words used in regular conversations between people. The inclusion of Repl-AI technology has also been done so that the chatbot can answer other questions that are not related to garbage, using the other keywords in the database. One such example was when a person typed the word "husband" into a message to the chatbot. To the surprise of many who were expecting a 404 error (i.e., the answer to the user could not be found), the chatbot sent an intelligent answer to the person with whom he was having a dialogue that amazed everyone: “Armand Salacrou once said "People get married because of lack of judgment, get divorced because of impatience, and remarry out of lack of memory." Why not try to train your patience? ” (Sea, 2017). No one expects a robot built and designed as a machine that helps sort and recycle garbage to give such an intelligent answer. This proves the variety and variety of keywords, vocabulary, and links between the sentences included in the model sentences used to develop an answer to a user's question and the intelligence of the people who worked on the chatbot database so that they can provide true, surprising, brilliant answers to messages you did not expect to exist in such a platform. Using quotation marks in chatbot responses to users avoids their annoyance, but leaves room for thought and meditation. Asked about this answer given by the chatbot, which included the word "husband", a representative of the Yokohama City Recycling Organization said: "We do not intend to give personal opinions.". Also, this Iio chatbot response is not just about using the word "husband." There are other terms included in the chatbot's vocabulary such as "marriage", "lover", "life", "anger" which, when used, will generate similar responses. (Sea, 2017)

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Conclusion

This paper is an argument for the global trend to use artificial intelligence in the field of the circular economy for the benefit of people and progress. The research work and the creativity of the specialists make amazing progress in the attempt to replace the human resource in some activities, in the fast and efficient development of some actions, in the accomplishment of some complex tasks. The circular economy consists of recycling waste, reducing pollution, maximizing the number of cycles spent by the raw material inside the system, and also the diversity in reuse along the value chain, in other words, about the maximum number of transformations and uses in different fields for a certain period.

This paper will be used in research based on studies on the circular economy and waste recycling, the need and usefulness of artificial intelligence in developing smart applications in the field of circular economy to help people recycle waste and have a cleaner environment andA little pollution, but there are also constant improvements that need to be made to the system, circular economy platforms, and smart applications that are used to recycle waste.Literatura de specialitate mentionata in lucrare ofera definitiile si principalele caracteristici ale celor doua concepte, precum si modalitatile de implementare a inteligentei artificiale in cadrul economiei circulare. Una dintre acestea este reprezentata de catre chatbot. Lucrarea prezinta doua modele de chatbot implementate in cadrul economiei circulare pentru a atrage atentia populatiei in ceea ce priveste mentinerea unui mediu cat mai curat.

The first chatbot model, A.I.R-e, is implemented in the city of Logroño (Spain) by TheCirculatLab and uses the latest features to provide useful information and provide data on various materials and places to be recycled. What makes it different from other chatbots is image recognition. The second chatbot model is called Iio and is implemented in Yokohama (Japan) by NTT Docomo. Its role is to provide support to the population on waste classification, the closest places where waste can be brought for recycling, and where the material should be disposed of.

In the future, we, the authors of this article, aim to develop such solutions, namely the creation of a chatbot and a mobile platform/application in the field of the circular economy. For this, it is needed to gather data to train the chatbot to be able to have a conversation with a person and give him an answer that the user can understand, but also the knowledge related to the circular economy to make a mobile platform/application that helps the population and in which this chatbot can be integrated.

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