Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Information Technologies

Bachelor Thesis

Robots in the Hospitality Industry: A Managerial Perspective

Sabanadze Marharyta

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

Marharyta Sabanadze

Economics Policy and Administration
Business Administration

Thesis title

Robots in the Hotel Industry: A Managerial Perspective

Objectives of thesis

The main objective of the thesis is to evaluate managerial perspective of using service robots in hotel industry.
The partial objectives of the thesis are:
-to analyze current state of the research on using robots in hospitality,
-to analyze the market of robots and identify the ones suitable for work in hotel industry,
-to conduct a survey among hotel managers in order to describe awareness, aptitude, and intentions of managers towards using service robots,
-to interpret survey findings and formulate recommendations for hotel managers.

Methodology

The methodology is based on studying of human-robot communication, in order to understand what should to be done so robots can interact with humans in an effective way. The own research will be based on Multi-Criteria Decision Analysis (MCDA) and a qualitative study (interviews) among hotel managers of different levels indicate their awareness, aptitude and intentions of using service robots in their business. Transcribed and coded interviews will be then interpreted with grounded theory approach, and the final recommendations will be formulated.

The proposed extent of the thesis

30-40 pages

Keywords

Robots, Hotel industry, Information and Communication technologies, Strategy.

Recommended information sources

IVANOV, Stanislav; WEBSTER, Craig; GARENKO, Aleksandra. Young Russian adults' attitudes towards the potential use of robots in hotels. Technology in Society, 2018, 55: 24-32.

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Expected date of thesis defence

2021/22 SS – FEM

The Bachelor Thesis Supervisor

Ing. Miloš Ulman, Ph.D.

Supervising department

Department of Information Technologies

Electronic approval: 29. 7. 2020

Ing. Jiří Vaněk, Ph.D.

Head of department

Electronic approval: 19. 10. 2020

Ing. Martin Pelikán, Ph.D.

Dean

Prague on 15. 03. 2022

Declaration

I declare that I have worked on my bachelor thesis titled " Robots in the Hotel Industry: A Managerial Perspective" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on date of submission 15.03.2022 Marharyta Sabanadze

Acknowledgement

I would like to thank Ing. Miloš Ulman, Ph.D. and his colleagues for their advice and support during my work on this thesis.

Robots in the Hospitality Industry: A Managerial Perspective

Abstract

The growth in tourism has led to a rapid expansion of the local hospitality industry, which is searching for innovative new sources of competitive advantage. The focus of development for service robots has recently shifted from the hardware to the application level, as consumer society has evolved to demand more value-added services from robots. This is a trend toward service robots which are designed to perform tasks in an unconstrained and human-centered environment. This thesis explores the design and role of robots in hotel service positions, as well as perceptions of hotel managers towards the utility of robots in their workspaces.

Keywords: *Robots, robot functions, hospitality industry, managerial perspective, innovation, competitive advantage, hotel service, Multi-decision criteria analysis, weighted scoring method, interviews.*

Roboti v pohostinství průmyslu: Manažerská perspektiva

Abstrakt

Růst cestovního ruchu vedl k rychlé expanzi místního pohostinství, které hledá nové inovativní zdroje konkurenční výhody. Těžiště vývoje servisních robotů se v poslední době přesunulo z hardwaru na aplikační úroveň, protože spotřebitelská společnost se vyvinula tak, že od robotů vyžaduje služby s vyšší přidanou hodnotou. Jde o trend směrem k servisním robotům, kteří jsou navrženi k provádění úkolů v neomezeném prostředí zaměřeném na člověka. Tato práce zkoumá design a roli robotů na pozicích hotelových služeb, stejně jako vnímání hotelových manažerů k užitečnosti robotů v jejich pracovních prostorech.

Klíčová slova: *Roboti, funkce robotů, pohostinství, manažerská perspektiva, inovace, konkurenční výhoda, hotelové služby, analýza vícerozhodovacích kritérií, metoda váženého bodování, rozhovory.*

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List of abbreviations

SAR – Social Assistive Robots
HRI – Human-Robot Interaction
AI – Artificial Intelligence
TTH – Travel, Tourism, and Hospitality
FO – Front Office

1. Introduction

The growth in tourism has led to a rapid expansion of the local hospitality industry, which is searching for innovative new sources of competitive advantage (Gomezelj, 2016). The nature of hospitality work has created many entry-level jobs with part-time work arrangements for seasonal employment (Baum, 2006). This has resulted in the delivery of service quality and attitudes that are affected by the emotions of inexperienced or part-time untrained front-line employees (Lovelock et al., 2015; Nickson et al., 2005) that will likely, gradually be replaced by automation and robotics technology.

The focus of development for service robots has recently shifted from the hardware to the application level, as consumer society has evolved to demand more value-added services from robots (Lee and Sabanovic, 2014; Zalama et al., 2014). This is a trend toward service robots which are designed to perform tasks in an unconstrained and human-centered environment (Haidegger et al., 2013; Kwak and Park, 2012). For example, humanoid robots can provide directions and guidance to customers at hotel reception (Mastrogivanni and Sgorbissa, 2013). This robotics technology solution can enable hotels to supplement human services by introducing new employee-based technology interfaces in the self-service delivery process.

This thesis explores the design and role of robots in hotel service positions, as well as perceptions of hotel managers towards the utility of robots in their workspaces. Thereby, the following chapters contain information, which enabled the comparison between hotel staff lists of functions and chosen robot models capabilities. As well, the qualitative study among 5-star hotel managers, in the form of interviews will be discussed in the following research.

2. Objectives and Methodology

2.1 Objectives

The main objective of the thesis is to evaluate the managerial perspective of using service robots in the hotel industry.
The partial objectives of the thesis are:

-To assess the current state of the art on using robots in hospitality,
-To analyze the market for robotic automation and identify the products that are suitable for work in the hotel industry,
-To survey hotel managers to describe awareness, aptitude, and intentions of managers towards using service robots,
-To interpret survey findings and formulate recommendations for hotel managers.

2.2 Methodology

The methodology is based on studying human-robot communication, to understand what should be done so robots can effectively interact with humans. The research will be based on Multi-Criteria Decision Analysis (MCDA) and a qualitative study (interviews) among hotel managers of different levels to indicate their awareness, aptitude, and intentions of using service robots in their business. Transcribed and coded interviews will be then interpreted with a grounded theory approach, and the final recommendations will be formulated.

3. Literature Review

Starting in late 2019, the Covid-19 pandemic began to interfere in human day-to-day life. For instance, social distancing has been promoted as one of the most important methods for avoiding the risk of infection. “History has shown that a crisis can bring about technological Innovation and development... robotics has grown increasingly more viable in hospitality and tourism industry settings to provide concierge, housekeeping, food, and other service tasks” (ZENG, et. al., 2020). Therefore, globally required safety precautions have pushed the market to automize the manual labor of high-risk in the hospitality and other industries with a frequent customer flow.

Robotics has recently shifted from the stuff of science-fiction to science-fact as more automation continues to overtake roles traditionally held by humans. For example, Haibin and Marcelo (2014) stated that “robots in public places refer to their use in museums, supermarkets, shopping centers, and childhood education centers”. Society’s development with the use of robotics to automate human roles is increasing in speed towards that becoming a reality soon. For now, however, robots don’t have a defined interface and intelligence that could do that, and society is still unsure where and how to apply artificial labor.

In fact, “the growing interest in robotics in travel, tourism, and hospitality raises the need for a systematic review of research on the topic and an identification of future research avenues in the field. Such a meta-analysis is currently missing from the literature” (IVANOV, et al., 2019). Therefore, the topic of robotics in hospitality is relatively new according to Ivanov Stanislav (et. al., 2019), who cites Schraft and Wanner (1993) and their research paper on an aircraft cleaning industrial robot “SKYWASH”; the first paper to ever discuss the use of a robotic product in a service industry. The research in this thesis complements the lack of meta-analysis on the topic of robots in the hospitality industry. This chapter contains a literature review about robotics and its expanding role in society. The chapter will also introduce terms such as human-robot interaction (HRI), artificial intelligence (AI), and different types of robots, especially social assistive robots (SAR) to sketch awareness of the current state of the art.

3.1 Robot Labor Necessity

Primarily, “service robots are considered a future workforce in hotels that could assist or even substitute human workers and reduce labor costs. Service robots are expected to deliver consistent, convenient, and efficient services” (CHOI, et al., 2020). As a result, robots were introduced to the hospitality industry to assist or substitute human labor. This would reduce the labor cost, in the way of excluding wages, but substituting the liability with robot maintenance costs. Accordingly, “the use of robots in hospitality services is another potential future trend. This development will have major social, economic and business effects” (BILGIHAN; NEJAD, 2015). Therefore, the following section will dive into the advantages of robotic labor in hospitality, based on the work of A. Bilgihan and M. Nejad (n.d.).

Starting with the social advantages generated by robotics in hospitality. “From a legal perspective, robots can help solve problems with employment turn-over (a robot does not require employment considerations), especially in countries with rigid employment laws and extensive bureaucracy. This would enable humans to concentrate on performing more revenue-generating activities that require reasoning… and enhanced service quality by incorporating smart technologies in creating experiences for tourists” (IVANOV; WEBSTER, 2020). Lastly,

robots could improve the quality of the services provided with better speed and precision when they are assisted by networked systems and devices.

When it comes to the business advantages, "positioning is one of the most important elements of strategic management or providing long term advantages for firms to be successful in the market. The positioning strategy is based on determining the capabilities of the competitors and offering a unique feature(s) to attract potential customers (SEYITOĞLU; IVANOV, 2020). In this respect, uniqueness is a significant component of positioning strategy. According to the positioning strategy, robotics in hospitality could bring more interest from the side of customers due to the unusualness of the presented innovation.

Furthermore, hotel environments include various services for which employees with specific skills are required. For this reason, robots of different physical appearances and skills have been developed for the hospitality industry. Artificial Intelligence or 'AI' can learn, but it is not always designed to learn, depending upon the needs of the application. AI may have varying degrees of learning ability, adaptability, and connectivity, for instance, hotel housekeeping service robots are designed as being capable of performing mechanical tasks such as making beds and vacuuming floors rather than interacting with guests" (HUANG; RUST, 2021). In this way, robotics can accurately assist or substitute human labor, due to specific design features that address repetitive or laborious tasks.

Robotics in the hospitality industry can also bring economic benefits. An example of this would be the global response to the Covid-19 pandemic. "In the early stages, governments' response to the pandemic required ceasing economic routines, e.g., hotels, restaurants, pubs, as well as travel bans (e.g., airlines). Consequently, millions of employees were sent home on paid or unpaid leave or were laid off. While companies struggled to stay liquid and pay their debts, demand for certain industries evaporated, causing immense labor shortages" (IVANOV, et al., 2020). The hospitality industry was one of those most affected by the lockdowns, affecting thousands of lives. This brought a bit of chaos to the industry; however, the pandemic experience has generated renewed interest in the idea of employing robotics more broadly in service-side hospitality.

3.1.1 Robotics Advancement

Currently, people are experimenting with robotic engineering with better integration to AI and machine learning capabilities. Giving robots a human-like appearance and rudimentary intelligence can appeal to human behaviors. A good example of a human-like robot is the *iCub*. "The *iCub* is a 53 degree-of-freedom humanoid robot of the same size as a three or four-year-old child. It can crawl on all fours and sit up. Its hands allow dexterous manipulation, and its head and eyes are fully articulated. It has visual, vestibular, auditory, and haptic sensory capabilities (GPL Metta Giorgio, 2010)".

The *iCub* is an open systems platform: researchers can use it and customize its hardware and software under the GNU General Public License (GPL Metta Giorgio, 2010). Thus, *iCub* is a wide-spectrum humanoid social robot constructed for general purposes involving human interaction. It was made to study cognitive manipulation (simulation of the movements and gestures) of humans and to emulate those with the perception of the surrounding environment, as well as associative recognition of human commands.

From this point of view, artificial intelligence (AI) is a simulation of human intelligence for learning and solving different kinds of human problems and advancing robotic decision-making. The learning process of the robot is mainly based on human-robot interaction – "For human-robot interaction (HRI), perception is one of the most important capabilities (Haibin, Marcelo, 2014)." Usually, such criteria as the ability to get and hold the user's attention are used to assess the quality of the social interaction between robots and people. The natural task of learning should be provided by a human, in a way of pronouncing keywords for a particular request and showing the precise way of performing the particular task.

The *Ke Jia* assisting robot was assembled with human-robot collaboration in mind and involved a learning algorithm to help emulate human behavior and reactions. According to Xioping Chen (2010) "robots should not be taken as tools, but rather as our partners… a variety of techniques for human-robot interaction have been developed, including spoken language recognition, gesture recognition, facial perception, etc." These are sometimes integrated with more traditional techniques such as a graphical user interface that humans can interact with and input commands that help the *Ke Jia* emulate human behavior. The *Ke Jia* robot is capable of understanding a variety of tasks that are both simple and complex. After the robot receives a request, the low-level command recognition begins with the robot analyzing the command by deriving the keywords from the command. A simple request would have only one keyword, for example:

Command "come <here>", the word <here> is a key word, more complicated requests would consist of 2 and more words, for example: "bring the <white> <pillow> from the <living> <room>", in case of complex request the priority of analyzing is to highlight the high-level key work, which can appear once per each complex task.

Hence, as there are many high-level words involved in the request, the more complex the analysis process becomes. After the recognition process is completed, the robot proceeds to initiate the moving plan linked by the request. "It would be too difficult or even impossible for the designers to specify beforehand all the necessary parameters of each high-level command. In these cases, the "high-level commands" propose infeasible demands on both users and designers" (Xiaoping, 2010).

3.1.2 Social Assistive Robots

The robotics industry is divided into several branches, each of them was created for a specific area of labor. Starting with *industrial robots*, they are focused on fast and high-quality industrial production e.g. manufacturing, fabrication, construction; the purpose of *assistive robots* is to provide physical assistance to disabled individuals or people who are going through rehabilitation; *assistive social robots* were developed for human-robot interaction, in this case, robots are taken as a social entity, with an ability to talk, walk, etc.*; service robots* are used as functional units which support basic human activities, such as household maintenance, etc.; *companion robots* are capable of providing companionship only and to improve the well-being of its users (Heerink, 2010).

A chart explaining a general categorization of robots, according to Heerink (2010), will be presented below:

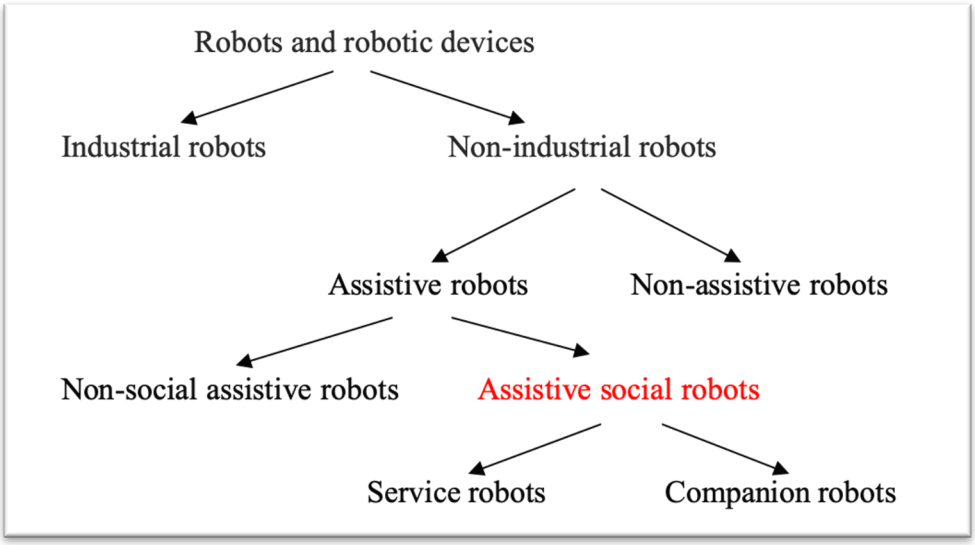

Figure 1. General categorization of robots

Socially assistive robots (SAR) are mainly involved in the long-term human-robot interaction (HRI). The Primary task of SARs is to assist users' decision-making and provide appropriate support and behavior. "SAR systems employ hands-off interaction strategies to provide assistance following a particular assistive context and to improve access to personalized care, training and rehabilitation to a wide variety of users, including elderly, to enhance their quality of life (UMBRICO, 2020)". An effective socially assistive robot should understand and interact with its environment, exhibit social behavior, focus attention on and communicate with the user, sustain engagement with the user, and achieve specific assistive goals.

Pepper is a humanoid robot designed primarily for HRI. The robot is capable of performing human-like behavior with the assistance of human-like drive units such as vision and audio sensors. *Pepper*'s design was grounded on cognitive science theories which are essential for productive HRI, as the robot is also capable of analyzing human speech and voice tones using proprietary algorithms (PANDEY, GELIN, 2018). *Pepper* can express emotions through the body language of its user and it also has a perception of the surrounding environment and the ability to move around.

Pepper was introduced as a shopping mall assistant in observations during demonstrations of *Pepper* in a mall, where researchers found that while children liked to play with the robot, adults asked for practical information about the robot's functions (AALTONEN, et al, 2017). "The appearance was characterized as "sympathetic" and positive because the robot was not too human-like. For interaction, the capability of *Pepper* to engage in social interaction by looking in the eyes (the robot turns its head and body to follow the face of the human by its "gaze") was experienced as impressive from the very beginning" (NIEMELÄ, 2017). Visitors left positive feedback about interaction with *Pepper*, the robot speaks clearly and waits for customers to respond in this way simulating a natural way of human conversation. At the same time being able to keep the customer interested in the conversation by asking additional questions (TUFIS, et al., 2019). Despite the fact of high expectations for human-like speech

simulation, people were positive about the robot-like appearance and speech manner - "*It is good to keep its behavior 'robot', not to pretend to be human, […], it looks like a robot, so it should be a robot*" (NIEMELÄ, 2017).

"Socially Assistive Robotics (SAR) focuses on assisting through social, not physical, interaction" (Feil-Seifer, 2005). The main principle of SAR is that the robot's appearance and general physical content creates an effective synergy between SAR and human. This type of HRI is essentially different from all other human-robot interactions, which don't involve physical embodiment. "Socially assistive robots can also serve as tutors, coaches, and companions, especially during interactions among students from different social groups and populations" (MATARIC, 2005).

NAO is a humanoid robot, which is a great instrument of multimodal HRI. *NAO* is a robot skilled with surrounding environment perception, human speech recognition, gesture, and body language production. "*NAO's* multimodal dialogue system design can be seen as an *artificially cognitive system*, which can communicate information to the user through synthesized speech. Such speech-based communication is grounded in *cognitive linguistics* research" (ONDÁŠ, 2017). Incoming information is analyzed by the multimodal output generation block, which divides information into sentences for precise analysis and after produces a combination of speech and gestures as a reverse reaction. Also, it has different modes of interaction, so after the text has been analyzed, the system generates reactions based on the selected mode which determines the best way of sentence processing.

There are three basic modes of interaction:
- *SpeechOnly*, the system generates only speech without gestures.
- *Randoff*, the system is searching for keywords and markups, which are then matched with gestures, the process is linked with manually programmed rules from configuration files.
- *Randon*, differs from the "Off" mode, in this case, the robot's random behavior is switched on, the robot generates random gestures and movements (ONDÁŠ, 2017).

NAO was tested in kindergarten using a storytelling mode. "At each session the robot initiated the storytelling procedure by entering the personal space of the seated children, greeting them, and explaining the current activity." (FRIDIN, 2014). After greeting and providing introductory games, *NAO* told the prerecorded story "*The Ugly Duckling*", while expressing emotions both bodily and vocally. While storytelling Robot was communicating with children, asking them if they know complicated terms from the story. If not, *NAO* explained specific concepts, for example, "reflection" or "ridicule". "Child's psychological profile, learning style, and social/cognitive-developmental stage play essential roles in kids educational process. *NAO* can provide feedback tailored to each child's psychological profile, learning style, cognitive and social developmental stage." (FRIDIN, 2014).

However, communication and interaction processes can appear between humans and robots or between robots and robots as well. As a consequence of robot-robot communication "researchers began applying principles such as stigmergy (indirect communication between individuals via modifications made to the shared environment) to achieve "collective" or "swarm" robot behavior. Stigmergy was first described by Grassé to explain how social insect societies can collectively produce complex behavior patterns and physical structures, even if each individual appears to work alone". (Fong, Nourbakhsh, Dautenhahn, 2003).

3.1.3 Service robots

"The field of robotics is currently changing. While in the past, robots were predominately used in factories for purposes such as manufacturing and transportation, a new generation of service robots has recently begun to emerge" (Schraft, Schmierer, 1998). Service robots cooperate with people, assisting in selected tasks. "Service robots are system-based autonomous and adaptable interfaces that interact, communicate and deliver service to an organization's customers" (WIRTZ, 2018). Service robots are getting information from information systems and sensors, using their operating system service, robots executing autonomous decision-making based on data they received, also they can learn on experience and store it in the knowledge base.

Furthermore, a good example of a service robot in hospitality would be the housekeeping robot, designed by Peanut Robotics and HLR corp. "The robot is designed to do supplemental housekeeping work alongside a human housekeeper, such as cleaning toilets and collecting linens, allowing housekeepers to focus on other aspects of their job" (VATAN, DOGAN, 2021). Interestingly, the robot is equipped with arms that enable the robot to hold and interact with objects. In practice, being able to perform continuous moves such as brushing or cleaning, as well as collecting and carrying objects.

Unfortunately, the housekeeping robot has been recently introduced to the market, which is why the detailed information about the robot's features is unavailable for the moment. However, the developers are planning to expand robot's abilities to minibar restocking and luggage carrying in the future, which would fulfill even more human doable tasks.

Roomba is a house-cleaning robot; it was developed as a time-saving solution for realty owners. *Roomba* is an automatic vacuum cleaning robot, "it uses a microcontroller to detect obstacles and manipulates its direction as per the inputs from infrared sensors mounted in front, right, and left of the robot or the digital signal processor. In case of an obstacle, or a potential collision, the microcontroller navigates the wheels of the robot by a motor driver to avoid collision" (PANDEY, Abhishek, 2014). The robot is capable of avoiding different types of obstacles and drop-offs using cliff sensors. These sensors constantly send infrared waves of signals which bounce back of any objects, by getting these signals back robot can analyze the distance between its position and an object, or otherwise, if the signal is not coming back, the robot understands that there is a drop-off, then the robot changes its direction of movement.

While cleaning process robot provides decision-making based on manually programmed data by the owner, via a smartphone app, e.g., location for cleaning, time of cleaning, and mode of cleaning. "Places like hospitals, restaurants and retirement homes can take an advantage of these devices where not much dirt is accumulated and can be cleaned easily with these devices" (PANDEY, 2014).

"Aeolus Robot is the first multifunctional in-home robot. Equipped with an agile arm able to dynamically manipulate household objects, the Aeolus Robot can recognize and adapt to changing environments and independently learn, navigate and complete tasks" (Suraya, 2018). Thus, Aeolus Robot is a multifunctional housekeeping robot, which can independently adapt and learn in an environment, while being able to fulfill following functions: "search for objects and being able to pick them up off the floor and put them away in their proper storage areas

(even remembering where it saw them last to help locate lost items); using vacuum or dry mop to clean floors; integrating with existing IoT systems including Amazon Alexa and Google Home; adapting to unique home layouts and routines" (Suraya, 2018). Therefore, Aeolus Robot will be efficient in any home-like environment, as the robot can learn and memorize the environment in detail. Also being able to vacuum clean and dry mop the floors, pick up objects and bring them where they belong based on the robot's object recognition.

"Service robots are being designed to become a part of the lives of ordinary people. Their tasks may range from entertainment or play to assisting humans with difficult or tedious tasks. In these kinds of applications, the robot will interact closely with a group of humans in their everyday environment" (SEVERINSON-EKLUNDH, GREEN, HÜTTENRAUCH, 2003). In each case service robot has a specific knowledge base that is built for a particular job a robot was developed for, that is the purpose of service robots.

3.1.4 Robot Functionality

"While there may be colloquial understandings of what a robot is, there is also a more technical and industry-accepted definition. A robot is defined as an "actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks" (IVANOV, et al., 2019). Ergo, according to the *ICube* robot model mentioned in the 'Robot Perception' chapter is it noticeable that robots are not always constructed for a selected labor market unit, like *ICube* some models are being constructed for purpose of studying or for scientific research.

However, models mentioned in the 'Social Assistive Robots' chapter e.g., *Pepper* and *NAO* robots have been constructed for a purpose that is demanded on the labor market - social assistance. However, the knowledge base for both *Pepper* and *NAO* can be changed according to the industry they are introduced to. This way *Pepper* and *NAO* implement the function they were constructed for, but additionally, they can be assimilated for narrow purposes of any industry where social assistance skills are required.

Moving forward, Hotels as they are, function relying on the inside structure, which hoteliers call "behind the curtains". The structure itself consists of necessary branches according to the Hotel rating, meaning that a 1-star hotel would not have a use for the branches which are necessary for a 5-star hotel. Suitably, robotic automation in the hospitality industry is taking over the simple tasks, "robots are involved in many services in hospitality, such as preparing drinks, entertaining guests, guiding guests and offering information to guests" (IVANOV, et al., 2019). Therefore, further research will dive into details about mentioned earlier robot doable tasks.

When it comes to the *Bartender robot* "a robot coexisting with humans must not only be able to successfully perform physical tasks but must also be able to interact with humans in a socially appropriate manner. In many social settings, this involves the use of social signals like gaze, facial expression, and language" (PETRICK; FOSTER, 2012). Furthermore, the bartender position does not only require a physical fit, thus a correct human-like response to the guests speaking. "As robots become integrated into daily life, they must increasingly deal with situations in which socially appropriate interaction is vital. In such settings, it is not enough for a robot simply to achieve task-based goals; instead, it must also be able to satisfy

the social goals and obligations that arise through interactions with people in real-world settings" (PETRICK; FOSTER, 2012). Therefore, besides beverage serving, the main task of this robot in the role of a bartender is to communicate in a satisfying and comfortable for the customer way.

Compared to the earlier reviewed *Bartender robot*, Barney Bar functionality is based on manual productivity, not the HRI. As it was stated on the official Barney Bar website, the robot bar is fully autonomous and able to serve any kind of beverage (Barney-bar.com., 2022). The bar is equipped with a collaborative robot arm, as well as an "integrated dispensing system, ice machine, cooler, screens, loudspeakers, order pad, wifi and perception sensors" (Barney-bar.com., 2022). Furthermore, the robot bar is capable of speaking, as well as playing music and showing videos, using its equipment. Lastly, the robot is also capable of customizing the drinks at a guest's request.

Moving forward to entertainment robots, *SDR-4X* is a humanoid robot, which was developed for childcare and entertainment. "SDR-4X can walk on uneven surfaces and perform adaptive motion control against external forces. Falling-over control of the robot is also realized by real-time adaptive control" (ISHIDA; KUROKI, 2004). Therefore, the robot can perform complete control over its body, due to the smart connections in between the parts of the body as well as 19 touch sensors that are allocated in various parts of *SDR-4X*, this enables the robot to keep up with the child's behaviorism. "It possesses perception, memory, ISM (Internal State Model), situated behavior generation components, sound localization, multi-face detection, and multi-face identification" (ARKIN, et al., 2003). Therefore, *SDR-4X* can recognize and memorize the user, as well as interact with exterior objects, while providing a situated behavioral response.

"During the interaction with a human, the EGO architecture remembers the emotional experience with that person, so that the robot can have different interactions with different people depending on the associated emotion with each individual" (ARKIN, et al., 2003). For this reason, *SDR-4X* can learn from human behavior, later on being able to vary its behavior according to the experience learned. "In addition, SDR-4X has two significant entertainment abilities, which are dancing and singing. SDR-4X especially uses its speech synthesis technology for changing the tone of its voice. Namely, with either a musical score or text data, SDR-4X can sing a song with the emotional expression" (ARKIN, et al., 2003).

Moreover, the "guiding guests and offering information to guests" (IVANOV, et al., 2019), are similar functions, because both are dependent on the pre-installed/learned data or available online information sources. Such as maps, inside the hotel configuration, or third-party businesses (e.g., restaurants, theaters, religious objects, etc.) and others for the guiding guest's function. And basic information such as public transport schedules, current exchange rate, weather forecast, etc., for the "offering information to the guests" function. Therefore, an example of a robot that can fulfill both functions, guide, and provide information will be presented below.

"*Jijo-2* was developed as an office-conversant robot that interacts with people daily, and their interactions were designed to achieve tasks such as providing information about a person and where the person is, guiding a visitor to a room, or explaining displays" (MITSUNAGA, et al., 2006). Most interesting, *Jijo-2* is capable of learning the office structure from a dialogue with its supervisor, according to the perception model reviewed in the 'Robot Perception' chapter. "Dialog-based map acquisition had been implemented, where the system learns a map

through making dialog with human trainers" (ASOH, et al., 1997). This way the learning process becomes more efficient and time-saving, compared to the classic programmed-in data.

"Currently the robot's vocabulary is approximately 50 words. The dialog control is very simple using templates of dialog patterns. Multi-agent software architecture a template for asking location is used to extract location names from the speech of humans. Some templates for answering simple questions from humans are also prepared" (ASOH, et al., 1997). Besides information provision reviewed earlier, the question asking and answering is the current challenge for the robot, due to the complexity of this activity as well as the robot's vocabulary shortage.

3.1.5 Summary

'Robot Labor Necessity' chapter presented benefits of robot labor adoption, including social, economic, and business advantages. Starting with social advantages, the robotics industry can reduce or avoid employment processes, which require fewer employees to process human resources in the first place. Furthermore, this would resolve seasonal labor instability and enable human employees to work on profit-generating activities instead of manual tasks.

Moreover, according to the presented earlier Covid-19 pandemic labor crisis, robotics is flexible in the way of being possible activated when required, same as being deactivated when no longer needed. This again resolves problems of hiring and firing employees, including reducing hotel costs of financial support of the employees when staying home during public businesses shut down. Thus, by implementing robotics labor costs could be also reduced, in the way of excluding wages, but substituting the liability with robot maintenance costs.

Furthermore, robotics in hospitality brings attention and curiosity from the side of customers, which plays as a business advantage. By offering guests an uncommon attraction, hotel popularity could raise, the same as the rating and profit rate.

Finally, robots can efficiently assist or substitute human labor, due to the engineering ability to assimilate to the hospitality industry. Robots are being developed according to various worker positions in hospitality, in this way each robot specializes in a certain job with an ability to learn.

In the 'Robot Perception' chapter, it was shown how the AI perceives human speech and how robots can extract meaningful information from the words heard. They are then able to fulfill the given tasks as well as store produced knowledge in the knowledge base to accumulate material for future critical thinking.

Furthermore, the 'Social Assistive Robots' chapter provides information about the robot assistance industry on the market. The industry itself is divided into branches, it becomes clear which segments of the industry are suitable for the given research - Social Assistive Robots and Service Robots. According to the examples reviewed in the 'Social Assistive Robots' chapter, the main purpose of SAR is to assist users' decision-making, providing appropriate support and behavior. Both robot models *Pepper* and *NAO* presented in the chapter, are capable of helping in decision-making by providing suitable information, in other situations being able to interact with humans informally, on the purpose of entertainment. Those tasks are being

followed with body language and voice intonations, which makes the interaction more habitual for any person introduced to the technology.

The following chapter 'Service Robots' clears out the difference between SAR and service robots. Compared to SAR, service robots are incapable of providing continuous HRI. According to the models reviewed, *Roomba*, *Aeolus,* and *Housekeeping* robots were constructed to perform physical tasks with little supervision required. These also do not require speech ability or body language, as service robots are being manipulated via touchscreen or smartphone app. Therefore, the purpose of service robots is to provide a specific function in mind.

Finally, the 'Robot Functionality' chapter provided robot model examples as stated by Ivanov Stanislav (et al., 2019). These included their functions such as - preparing drinks, entertaining guests, guiding guests, and offering information to guests. Three robot models were presented - *Robot Bartender*, being able to execute drinks preparation; *SDR-4X*, a robot which was developed for purpose of entertainment; *Jijo-2*, an office-conversant robot, which can guide and provide available information.

The above models will be introduced again later in the classic 5-star hotel crew members' responsibilities – front office clerk, bartender, and room entrant, which are selected in the 'Hotel Structure' chapter presented below. Functions of the selected positions will be compared to the reviewed robots' abilities, to understand how successful robots can substitute human labor in the hospitality industry.

The classifications of the robot models are expressed below according to the typical hotel positions:

Front office clerk – NAO, Pepper, Jijo-2
Bartender – Bartender Robot, Barney Bar
Room entrant – Roomba, Housekeeping robot, Aeolus robot

3.2 Hotel Functioning

To investigate the hotel environment accurately, considering all possibly occurring issues, the following research is based on a 5-star hotel structure. The Hotel Chain is a system of hotel facilities, headed by a central management branch. The Chain system supports corporate standard in a range of services defined by economic policy and reservation system, which unites all hotel functioning branches." (WŁODARCZYK, 2003, p. 57). The most important criterion in the concept is centralized governance, which supports defined corporate policy in culinary and hospitality services. This is not only applicable to hotel chains but to single hotel facilities as well. Furthermore, besides a corporate standard, hotels are also supposed to follow the international hotel classification. "According to DEHOGA, the German Hotel and Restaurant Association, hotel classification was created ensure transparency and quality of hotel standard to help customers determine what sort of conditions they can expect for the price they are paying" (CSER; OHUCHI, 2008). Accordingly, the hotel classification system was implemented to unify the ratings of the hotels which would make clear for both hotels and guests the interrelation between money and service.

Since hotel education began to form as an industry, the need for skilled and qualified labor became required as well. "Some four-year hospitality programs began to respond to the demand

for increased professional skills by focusing on the particular needs of the hospitality industry". (CHUNG, 2000). The following research is based on *'Organization of the work in hospitality'* (Bocho et al., 2006), which is a cornerstone of the state of the art concerning the hospitality industry. This source contains all needed information about international hospitality regulation and hotel work structures, such as front office, culinary and housekeeping branches.

3.2.1 Department overview

3.2.1.1 Reception clerk list of functions

The main function of the reception front desk is to provide services related to accommodation, guest services, and providing documentation based on local state requirements. Organization and supervision of work at the front office (FO) is a part of the FO manager's responsibilities. Furthermore, the FO manager is responsible for the supervision of work at the front desk as well as cooperation between the front desk and others hotel branches.

A detailed list of regular FO clerk responsibilities include:

- Reception of guests and room key issuing.
- Records keeping based on local state requirements.
- Organization of guest's luggage transportation assistance during check-in/check-out processes.
- General information providing (e.g., public transport schedule, opening and closing time of museums, expositions, theatres, cinemas, sport and art meetings, availability of national attractions, SPA centers, exchange rate, etc.), Information about possible accommodation offers, in a city, in a state, and a country.
- Implementation of guest wishes (culinary orders, complementary services, taxi orders, from individual customers and tourist group members as well)
- Guest's mail storage or delivery on the request.
- Acceptance of personal guests' belongings to the deposit safes, according to obligatory international hospitality norms.
- Calling emergency services such as ambulance, firefighting service, or police in a situation, when the intervention of these services is required (ibid).

Back-office FO clerk responsibilities are:

- Analysis of rooms statuses and integrity.
- Analysis of late/early check-ins/check-outs and voucher payments.
- Keeping records and documents related to funds acceptance
- Preparation of daily report about hotel occupancy.
- Efficient and open cooperation with all others hotel branches.
- Transmission of information about the hotel occupancy forecasting to heads of housekeeping and culinary branches (ibid).

3.2.1.2 Bartender list of functions

When it comes to the culinary branch in a hotel, it is important to underline that this branch consists of 3 main fields which cooperate. However, all of them have different tasks and approaches. The fields are the kitchen, restaurant, and bar. Most commonly those fields have a simple hierarchy consisting of the head of the field and his/her subordinates. In the kitchen, it would be the chef and sous chef, and cooks who are allocated to separate tasks. In the restaurant

– hall manager and waiters. Lastly, head bartender and bartender assistant at the bar, however, it is common the bar is being held by one clerk only and being supervised by the hall manager.

The bartender's responsibilities are:

- Everyday bar set up preparation.
- Procurement of the needed raw materials and beverages.
- Working space and equipment cleanliness maintenance.
- Cocktails and other beverages preparation and serving.
- Finances and documentation about transaction keeping.
- Tracking the amount of the raw materials and beverages sold.
- Assortment provision according to the beverage menu.
- Conversing with the guests if suitable (ibid).

3.2.1.3 Room enterant list of functions

The housekeeping branch is a guarantor of the product quality, their role is to keep the hotel clean and good-looking. Workers of this branch should be less seen by guests, in fact, Hotels usually have a special area for this crew to function in, (e.g., personal corridors and elevators, staff rooms, etc.). Housekeeping is an independent branch that consists of a maid, floors manager, room inspector, bed linen storekeeper, head of laundry field, laundress, and ironer.

A detailed list of a room entrant responsibilities include:

- Performing tasks and requests set by room inspector.
- Maintaining cleanliness in rooms, working areas, and public places (e.g. corridors, lobbies, etc.), at the same time not disturbing guests by own work.
- Adhering to rules related to bed linen and towels change, also refilling all washing liquids in bathrooms.
- Careful usage of cleaning chemicals.
- A brief check of all electronic devices in the rooms, to make sure that they function well.
- Make sure that nothing from the room equipment is broken.
- Report on broken devices or equipment in rooms or corridors should be provided immediately.
- Guests' wishes and remarks should be reported as well.
- Looks after guests and guests' belongings safety, discreetly looks after people in corridors, and informs reception in a situation when regulations or policy wasn't respected by guests.
- Checks the room status right after guests left the room.
- Packs used laundry for washing.
- Provides daily reports about cleaning (ibid).

3.2.2 Managerial Standpoint

"The hospitality industry is an intensive labor industry, and service-oriented business, the hotels are anxious to attract and retain qualified employees, because they are vital major assets for hotel success, and hotel industry prosperity" (FATHY, 2018). Thus, human labor is one of the most important elements of any hotel's day-to-day functioning. Since hospitality is a service industry, it circulates employees according to their skills and physical appearance.

Moreover, recruitment of employees in hotels "involves assessing candidates and selecting the most suited ones to fill the vacant positions. The need for the selection of employees

becomes crucial because it determines the success of an organization. No organization can grow effectively unless the proper recruitment and selection procedure are carried out effectively" (BAKO; ALADELUSI, 2017). Therefore, recruitment is a complicated time-consuming process, which usually involves applicant search, resume revision, and interview realization (CHAN; KUOK, 2011). In addition, recruitment of suitable employees is crucial because the overall success of hotel structure functioning is in direct dependence on workers recruitment.

Furthermore, employee recruitment is the first step in productive cooperation, later the relations will have to include employee motivation and retention. "Motivation is the performance or procedure of presenting an intention that origin a person to capture some accomplishment. … Derived from the word "motivate", means to move, push or influence to proceed for fulfilling a want" (MANZOOR, 2012). Accordingly, to receive thoughtful and willing input from the employees, the employer has to find a way to tune the employees.

When it comes to employee retention: "the negative aspects of the hospitality industry include the sacrifice of private life, invasive and long working hours and these can lead to raising the turnover level. … Employee retention strategies should consider both work and life components" (FATHY, 2018). Consequently, the hospitality industry requires employees to sacrifice their private life to cope with the workload, which is one of the common reasons for employees to experience uncertainty in their engagement. Furthermore, the not only workload can turn the employees away, but also competition for promotions due to the hierarchy structure in the hospitality industry (FATHY, 2018).

Moving forward, developing employees' skills inside of an organization has certain advantages for any hotel. "Employee training is a strategy for developing people within an organization. Increasing the job knowledge and skills of employees are the intended outcomes of employee training. Employee training is intended to upgrade employees' job-related knowledge, attitudes, skills, and competencies for current and future job requirements" (WAQANIMARAVU; ARASANMI, 2020). Therefore, employee training is crucial for the hospitality industry due to each hotel's uniqueness in the service provision. Training employees with previous work experience in a hotel is being done to show the specialties of the work environment and qualify an employee to provide services according to the brand standard and corporate policy of a certain hotel. The same is being done with employees with no previous work experience, also to make sure that the employees are completely aware of all specifics of the service provision.

Besides the actions that hotel management must implement, as mentioned, employee motivation, retention, and training are the actions taken by the company according to its interest in long-term cooperation with qualified employees. Some actions need to be considered about the personal goals of the employees as well. "Employee performance fundamentally depends on many factors like performance appraisals, employee satisfaction, compensation, personal development, job security, organizational structure and others" (MANZOOR 2012). Hence, to build well-functioning personnel, the employer has to sort out suitable candidates for the recruitment, train them and create a comfortable environment for them to be personally satisfied, and for the employer to hold on to the qualified staff.

The second part of this section will dive into robot management in hospitality, to understand what complications could appear whilst operating robots. To start with, robotics in hospitality is still an untested novelty, since it is still unknown what challenges might be met

along the way of adaptation of the presented technology. “The design of robot-friendly hospitality facilities has been completely ignored, largely due to the currently limited adoption of robots by travel, tourism, and hospitality companies. However, as robots become more widely used by both companies and customers, the design of robot-friendly hospitality facilities would become a major issue for architects, engineers, owners, and operators of such facilities. Companies need to plan and be ready for the influx of service/social robots expected to flood into their enterprises in the next 10 years” (IVANOV; WEBSTER, 2017). Thereby, the implementation of the robot workers in the hospitality industry will require beforehand preparation of the environment. This might not only mean replacing interior objects to provide larger space for robot services provision. Thus, robot staff adoption might also require projecting the future constructions with awareness of robot required environment features.

Furthermore, robotics, as any information technology, could require routine maintenance or repairs in case of hardware or software fault. “The response to the threats factor raises the alarm on issues of repair and maintenance requiring a human engineer on-site for constant management. Maintenance issues of service robots could increase the cost of maintenance and reduce the time of use of the service robot, thus delivering a failed service. Robotics failure during service interaction may result in hotel embarrassment or even customer injury, leading to a negative customer judgment” (KUO, et al., 2016). Consequently, robot maintenance could cause redundant expenses, including a need for an around-the-clock robot technician.

3.2.3 Summary

The ‘Hotel Functioning’ chapter contained information on the hotel worker's functions and the managerial standpoint on human and robot workers in a 5-star hotel. Starting with corporate standard and international hotel classification. Corporate standard is the set of rules and regulations stated by the hotel head management, whereas international hotel classification was established for the hotel ratings to coincide with the defined metrics, which would make clear for both hotels and guests the interrelation between money and service.

Moreover, the research on the hotel structure is based on the *‘Organization of the work in hospitality’* (Bocho et al., 2006) book, contained information about a unified international approach to hospitality regulations, and are supported by educational institutions. Furthermore, the research includes front office, culinary, and housekeeping branches review, from which selected worker's functions will be compared to the robots’ models introduced earlier.

The front office branch provides services related to accommodation, guests service, documentation storage. FO branch consists of FO manager and the receptionists. Complete FO clerk list of responsibilities had been reviewed in the ‘Hotel Functioning’ section. The front office cooperates with all the hotel branches to achieve customer satisfaction and vice versa.

Moving forward, culinary is a large independent branch, which takes over the restaurant area in a hotel. The restaurant area consists of 3 main sectors: kitchen, restaurant, and bar. Each sector has its hierarchy, which allows the routine to flow smoothly and organize. ‘Hotel Functioning’ section reviews the list of responsibilities of a bartender.

The housekeeping branch is the guarantor of cleanliness in a hotel. It consists of various workers, mainly divided into executing workers and examining workers. Meaning that any freshly cleaned area will be checked by a corresponding worker to make sure that everything

was done according to the standard. The ‘Hotel Functioning’ section reviews a list of responsibilities of a room entrant.

The ‘Managerial Standpoint’ section contains information about the drawbacks of human and robot labor. Starting with human labor, to recruit employees from potential candidates by reviewing their CVs and conducting in-person interviews and assessments. Later on, an interview process is undertaken to decide which of the candidates will fit the vacant position well. After the recruitment processes had been settled, the employee will be trained according to the hotel standard requirements. However, recruitment is not the only complication along the way of staff formation, but the retention is a threat to long-term efficient cooperation between the hotel and its employees. Retention includes many points for consideration, such as employee motivation, satisfaction, personal development, compensation, etc. To build a well-functioning longlisting crew in a hotel, the points from above should be respected.

Moving on to robotics in hospitality -- this innovation is quite untested yet, for this reason, it might not be completely clear what complications could be met by adopting robotics in services traditionally held by humans. Firstly, robotics do require a particular working space design, for robots to work efficiently. This might not only require minor interior adjustments but the whole facility reconstruction, depending on the existing structure. Additionally, robots also require maintenance provision by a qualified technician.

4. Practical Part

The following chapter is addressing the compatibility of SAR robots with hotel day-to-day functioning, based on robotics' current state of the art and 5-star hotel work requirements. Therefore, robot models and their capabilities mentioned in the literature review chapter will be introduced to the hotel work requirements as mentioned in the literature review chapter. Furthermore, the compatibility will be estimated using the Multi-Criteria Decision Analysis. The practice of multi-criteria decision analysis (MCDA) is concerned with the evaluation of a set of possible courses of action or alternatives. This evaluation may take several forms – selecting a preferred alternative, ranking alternatives from best to worst, sorting the alternatives into ordered classes such as 'good' or 'bad', among others (DURBACH, STEWART, 2012).

Furthermore, semi-structured interviews were conducted among twenty 5-star hotel management professionals in Prague. These interviews reveal key themes relating to the perceived use of robots in the hospitality industry, as well as identifies interviewed hotel managers' awareness, aptitude, and intentions of using service robots in their business.

4.1 Research Justification: Dataset and its Limitations

Firstly, it must be explained that the project has obvious limitations in terms of achieving primary data about robotics. For instance, research of this kind typically involves machine learning, highly advanced engineering and computer science work, and the use of robotics in service industries is still very nascent, and as such, it is difficult to discover qualitative data about the performance of robotics in service positions, namely in hospitality.

With that said, the researcher elected to perform an MCDA on a selection of primary and secondary data qualitative data. The primary data was collected in semi-structured interviews with subject matter experts such as hotel management professionals from several five-star resorts in the center of Prague. It should be reiterated, that the goals of this research are to perform a comparison of the robotics capabilities according to the traditional roles and functions of the hotel staff. Therefore, qualitative data is most appropriate here, and the interviews (supplemented with literature) should suffice as the basis for rating the compatibilities of several designs according to the traditional service functions that they are proposed by their makers to replace.

The secondary data will be supplemented with the given literature referenced in the previous chapter, as the corresponding information about robotics in service industries more readily comes from the designers and scientific articles about specific robotic designs and their proposed uses. This is the main limitation of the research since access to such designs is not only expensive but often restricted due to their sensitive intellectual property rights. Suffice it say, the research could not find access to view the robotic models personally. So, achieving unbiased access to the models that will be compared herein is not possible with the given scope of this project. Nonetheless, this work can catalyze for others to review the viability of robotics in service industry positions given the insights of the primary data (interviews with hotel management professionals) treated with the MCDA.

4.2 Multi-Criteria Decision Analysis

Multi-Criteria Decision Analysis is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making in a variety of settings. In this case, The MCDA is used to measure and evaluate several different robot types and their ability to complete specific tasks in a hotel business environment. In general, MCDA helps structure complex problems and consider multiple criteria to find more informed and better decisions about something, in this case, investment in robotics for hospitality.

The MCDA has its roots in Stanley Zionts' 1979 article "MCDM – If not a Roman Numeral, then What?", intended for an entrepreneurial audience. Therein, Zionts stated that the MCDA is best used for deriving unique solutions to complex business problems, whereby it is necessary to use decision-makers preferences to differentiate between solutions (1979, 14). The popular view of strategic decisions in a business environment is that they typically involve a high degree of uncertainty, high stakes, major resource implications, and long-term consequences (JOHNSON, et al., 2008). This view is associated with the traditional conceptualization of strategic decisions as to the product of intentional attempts at rational choice and context-setters for subsequent strategic action (EISENHARDT, 1992).

Among the many fields where MCDM is applied (computer software selection, project selection, and system selection), materials selection is certainly one of the most crucial. This is also true in business environments such as a hotel, where searching for new ways to improve business functions and activities is a multi-dimensional problem, "with many boxes ticked at the same time" (CURTAROLO et al., 2013, 191-201). Changing the materials set in an established technology, such as the introduction of new software or tool, is a rare event and can be considered as a revolution (ibid). Furthermore, materials selection is the prerequisite for a chain of different selection problems, such as process selection, machine selection, tools selection, material handling equipment selection, supplier selection, and personnel selection (JAHAN and EDWARDS, 2015). In other words, investment in robotics not only affects future material investments involved in maintaining a hotel, but also the staff and vendors that are traditionally essential to the business.

Unlike the exact sciences, where there is usually only one single correct solution to a problem, the MCDA simultaneously considers the conflicting advantages and limitations, necessitating compromises and trade-offs; and as a consequence, proposes different satisfactory solutions where possible (FARAG, 2002). MCDA addresses the need for a numerate structure (CHARLES et al., 1997) in the selection process according to a criterion. A variety of different methods for determining criteria weights in MCDA have been developed, such as the swing method (VON WINTERFELDT & EDWARDS, 1986), trade-off method (KEENEY & RAIFFA, 1976), AHP (SAATY, 1977), and SMART (EDWARDS, 1971), to name a few. The criteria weights are generally treated as deterministic and are usually determined on a subjective basis.

The uncertainty in the elicited weights can influence the resultant ranking of alternatives. In MCDA, aggregates are used for the different values of the utility functions, in our case, the tasks typically performed by human beings in a hotel setting. Some performance values in MCDA problems are often subjective and changeable. Aggregation could yield inconsistent results since the weights of criteria and the scoring values of alternatives against the judgmental criteria always contain some uncertainties. It is an important issue how the final ranking or the

ranking values of the alternatives are sensitive to the changes of some input parameters of the decision problem (TRIANTAPHYLLOU & SANCHEZ, 1997; MEMARIANI, et al., 2009).

4.3 Weighted Scoring Method

A weighted scoring method (a.k.a. weighted appraisal method or weighted scorecard) is a project management technique used for weighing certain decisions, such as prioritizing project actions or the development of product features, purchasing new software/hardware, materials, accessories to improve business functions, etc. (MORPUS, 2021)... The weighted scoring method is often used by researchers in operations management to determine the value of certain criteria according to environmental or social factors (NURSAL, 2005). In this case, several robotic designs are scored according to their ability to perform tasks in the hospitality industry, cross-referenced of course with the

The weighted scoring method exists to prioritize the analysis of multiple conflicting criteria based on empirical assessments (BASKARAN and MUTHU, 2018). Using this method enabled the researcher to highlight the highest priority functions and characteristics of the cases in question. However, before making calculations, assigning weight values to each criterion is necessary, which means that a 'weight' is the percentage of priority of a particular value. In our case, the researcher calculates the efficiency of robots in hospitality, including all possibly accomplishable tasks.

In table 1 the criteria are given a general value and description, labeled as 'importance of task', between the ranges of 'medium', 'high', and 'low importance'. This labeling is not arbitrarily chosen, but rather taken from the literature as mentioned in the justification of this project and later cross-referenced with interviews with professionals from a 5-star hotel setting. The following tables are divided into two columns: 'task' and 'importance' which contain the rating of the tasks – High (most important), Medium (important), and Low (less important). The categories were assigned according to the significance and immediacy of a particular task realization:

Table 1. Front office/reception tasks

№	Task:	Importance of the task (weight):
1	Reception of the guests (casual conversation)	Medium (2)
2	Documentation keeping based on local state requirements (billing, guests' personal information)	High (3)
3	Organization of guest's luggage transportation assistance during check-in/check-out processes	Low (1)
4	General information services	Medium (2)
5	Implementation of guest wishes (taxi order, restaurant reservation)	Medium (2)
6	Guest's mail/parcel storage	Low (1)
7	Acceptance of personal guests' belongings to the deposit safes/storages	Low (1)
8	Calling emergency services (ambulance, firefighters, police)	High (3)

9	Room key issuing	Medium (2)
10	Analysis of rooms status and integrity	Medium (2)
11	Analysis of late/early check-ins/check-outs and voucher payments	Low (1)
12	Transmission of information about the hotel occupancy forecasting to heads of housekeeping and culinary branches	High (3)

Furthermore, a wider explanation of these tasks is given below:

№1 Reception of the guests (casual conversation) – This task is of medium importance as it is a general requirement by hotel staff to engage in casual conversation and present a helpful atmosphere during interpersonal interactions. All staff ought to be prepared to provide immediate assistance and offer appropriate solutions with immediacy.

№2 Documentation keeping based on local state requirements (billing, guests' personal information) - This task requires all the standard documentation to be formed and stored incorrect order. This task is of the highest importance as all operations about the guests' stay are dependent on the information that is collected and stored. It includes in-department and inter-department functions, as well as any documents or information required by third parties, i.e., online booking service, event reservations, airport shuttles/taxis, loading/off-loading guest belongings via valet services, et cetera.

№3 Organization of guest's luggage transportation assistance during check-in/check-out processes – This task is considered a low priority because it is not complicated and it is not necessarily a core function of the front/office reception. Rather it is the responsibility of the bellman service, which is a sub-office of the reception.

№4 General information services – The informational needs of the guest may require minor contact for which hotel staff members ought to be prepared, e.g., able to provide directions, transportation schedules, general event information, et cetera.

№5 Implementation of guest wishes (taxi order, restaurant reservation) – This task is considered of medium importance as it is an extension of task **№4**. This task usually follows up on general information services in that the corresponding request from the guests requires inter-personal contact and the service of organizing guests' needs in a timely and appropriate manner.

№6 Guest's mail/parcel storage – This task is considered of low importance, as the receiving and storing of guest's mail or parcels are not complex and usually involve back-office storage of guest-related utilities.

№7 Acceptance of personal guests' belongings to the deposit safes/storages – This task is considered of low importance, as it is not complicated to fulfill and parallel task **№6**, in that the solution to receiving and storing guest belongings usually involves secure storage of valuables in a safety deposit box or locker in the back-office.

№8 Calling emergency services (ambulance, firefighters, police is a high-priority task that often requires some level of training in emergency management. All staff is required to understand their role in an emergency and act appropriately according to the protocol for

specific situations. These can include, calling emergency services, engaging emergency protocols such as fire suppressant system, limited medical assistance, evacuation of guests, et cetera.

№9 Room key issuing – This task is a low priority task, as it is not overly complex, and it is a common function of the front-office reception. Most staff that fulfill this function have been trained to issue room keys and the correct storage of related guest information to issued rooms.

№10 Analysis of rooms status and integrity – This task is a medium priority as it is usually the function of housekeeping, however, the staff that fulfills this role must coordinate closely with the front office and be updated as to the state of rooms after guests are checked out. For instance, in some cases, guests may be required to pay a deposit as collateral to cover damages and misuse of hotel property.

№11 Analysis of late/early check-ins/check-outs and voucher payments – This task is a low priority, as it is an uncomplicated function of the reception/front office that requires menial data entry into the hotel reservation system. It may also require recognizing voucher payments and discounts and processing those with the guests' overall payments for their stay.

№12 Transmission of information about the hotel occupancy is a typical function of the reception/front office that requires the processing of information related to accommodation and occupancy. The front office is responsible for sharing essential information with other departments and coordinating operations accordingly. This can also include forecasting schedules to the heads of other departments such as housekeeping and culinary branches.

Table 2. Bar related tasks

№	Task:	Importance of the task (weight):
1	Bar set up/preparation	Medium (2)
2	Procurement of the needed raw materials and beverages	High (3)
3	Working space and equipment cleanliness keeping	High (3)
4	Cocktails and other beverages preparation and serving	High (3)
5	Finances and documentation about transactions keeping	High (3)
6	Tracking the amount of the raw materials and beverages sold	Medium (2)
7	Assortment provision according to the beverage menu	High (3)
8	Reception of the guests (casual conversation)	Medium (2)

Furthermore, a wider explanation of these tasks is given below:

№1 Bar set up/preparation – This task is a medium priority since it is the basic starting requirement for opening the bar and preparing related services for guest use. Staff that fulfills this task have some training to do this but are generally not too complicated.

№2 Procurement of the needed raw materials and beverages – This is a high-priority task that requires producing inventory requests and procuring beverages, perishable items such as fruits, snacks, napkins, glasses et cetera. It is considered a high-priority task because these materials are required for the business operation of the bar and typically require the bar supervisor to calculate costs and organize accounting for the materials.

№3 Working space and equipment cleanliness keeping – This is a high-priority task that requires the bar staff to maintain a high standard of cleanliness of the bar seating area.

№4 Cocktails and other beverages preparation and serving – This is a high-priority task that parallels tasks **№2** and **№3**. As with those tasks the preparation and serving of bar services, e.g., cocktails, snacks, and other beverages, is a core component of the business operation in this section of the hotel. This requires training and demonstrable skill in bartending services.

№5 Finances and documentation about transactions keeping – This is also a high-priority task that requires training in the use of the hotel accounting system, cashier operation, and correct calculations. Staff that performs this duty are required to undergo extensive training and performance review to ensure that the financial accounting of transactions is accurate.

№6 Tracking the amount of the raw materials and beverages sold – This is a medium priority task that parallels task **№2**. The tracking sales and inventory is functioning the bar staff that requires some training in the inputting of sales at the end of business hours and accounting for inventory materials.

№7 Assortment of inventory provisions according to the beverage menu – This is a high-priority task that also parallels tasks **№2** and **№4**. Bar staff must sort inventory provisions such that they accurately reflect the menu.

№8 Reception of the guests (casual conversation) – This is a medium priority task that requires bar staff to be able to engage in verbal contact with guests.

Table 3. Housekeeping tasks

№	Task:	Importance of the task (weight):
1	Performing tasks and requests set by room inspector	High (3)
2	Maintaining cleanliness in rooms, working areas, and public places (e.g., corridors, lobbies, etc.), while not disturbing guests	High (3)
3	Adhering to rules related to bed linen and towels change, also refilling all washing liquids in bathrooms	High (3)
4	Careful usage of cleaning chemicals	High (3)
5	A brief check of all electronic devices in the rooms, to make sure that they function well	Low (1)
6	Make sure that nothing from the room equipment is broken	High (3)
7	Report on broken devices or equipment in rooms or corridors	High (3)

8	Guest's wishes and remarks should be reported as well	Medium (2)
9	Looks after guests and guests' belongings safety, discreetly looks after people in corridors, and informs reception in a situation when regulations or policy wasn't respected by the guests	Medium (2)
10	Checks the room status right after guests left the room	High (3)
11	Packs used laundry for washing	Low (1)
12	Provides daily reports about cleaning	High (3)

Furthermore, a wider explanation of these tasks is given below:

№1 Performing tasks and requests set by room inspector – This is a high-priority task that housekeeping staff is required to perform according to the protocols set by the room inspector who is typically a manager.

№2 Maintaining cleanliness in rooms, working areas, and public places (e.g., corridors, lobbies, etc.), while not disturbing guests – A high priority task that corresponds to the core business activity of maintaining high-quality cleanliness and presentation of guest's rooms and public spaces. This also extends to sections of the hotel accessible only to staff members.

№3 Adhering to rules related to bed linen and towels change, also refilling all washing liquids in bathrooms – This is a high priority task that requires the housekeeping staff to be familiar with the rules a procedure for organizing the cleaning activities of guest rooms and ensuring the replenishment of used compliments, e.g., towels, mini-bar, bedsheets, et cetera.

№4 Careful usage of cleaning chemicals – This is a high-priority task because it is requiring housekeeping staff to be familiar with safety protocols concerning the use of cleaning equipment. For instance, common cleaning materials have chemical components that can be harmful if misused.

№5 Brief check of all electronic devices in the rooms to make sure that they function well – This is a low priority task where housekeeping staff should be familiar with the proper functioning of guest room electronics, e.g., making sure phones, television is plugged in, and/or wireless connectivity is functioning properly in all sections of the hotel.

№6 Making sure that nothing from the room equipment is broken – This task is considered a high priority that follows up on task **№5** whereby housekeeping staff should have at least one team of maintenance staff that are attached to the housekeeping department. These individuals are responsible for following up on reports of broken equipment and fluffing routine maintenance to ensure all equipment in the guest rooms works properly.

№7 Report on broken devices or equipment in rooms or corridors – Similarly to task **№6,** task **№7** is a high priority task that requires housekeeping staff to be familiar with the reporting protocols of broken equipment and relaying that information to the maintenance team.

№8 Guests' wishes and remarks should be reported as well – This is a medium priority task of the housekeeping department that requires staff to be ready to interact with guests and deliver their requests or remarks to the front-office, who in turn, will relay the appropriate solution back to the housekeeping department who will deal with the requests promptly.

№9 Looks after guests and guests' belongings safety, discreetly looks after people in corridors, and informs reception in a situation when regulations or policy wasn't respected by the guests – This is a medium priority task that requires housekeeping staff to be alert and aware of safety protocols concerning lost belongings and/or misbehavior by guests that contradict hotel policy, as well as reporting such incidents to the front-office.

№10 Checks the room status right after guests left the room – A high priority task that concerns the core function of checking on the room status after guests have left the room for checkout. This task requires housekeeping staff to make an inventory of complimentary items in the room and a survey of electronic devices, furniture, and the general state of the room.

№11 Packs used laundry for washing – This is a low priority task because it is not overly complicated and requires housekeeping to perform menial tasks associated with collecting used sheets and laundry from guest rooms and delivering them to the washing facilities that are on-premises.

№12 Provides daily reports about cleaning – A high-priority task that requires housekeeping staff to be familiar with the reporting protocols concerning the readiness of rooms to be occupied by new guests after previous guests have checked out. This information is also communicated and coordinated with the front office to maintain accurate forecasting of guest room availability.

4.4 Semi-Structured Interviews

A semi-structured interview is a method of research used most often in the social sciences. While a structured interview has a rigorous set of questions that do not allow one to divert, a semi-structured interview is open, allowing new ideas to be brought up during the interview as a result of what the interviewee says. The interviewer in a semi-structured interview generally has a framework of themes to be explored (Edwrds and Holland, 2013). Semi-structured interviews are widely used in qualitative research for example in household research, such as couple interviews. A semi-structured interview involving, for example, two spouses can result in the production of rich data, including observational data (Bjørnholt and Farstad, 2014).

The interviews make up the core of the study's insights and were organized using a questionnaire that involved gauging and probing for the normative problems and perceptions among the interviewees concerning robots in the hospitality industry. Each session was approximately 30 minutes in length (some were given longer based on their willingness to speak and availability) to allow in-depth responses. The researcher utilized a general interview guide format, which was oriented around semi-structured interviews.

Interviews were conducted individually so that information, responses, and observations would occur in isolation from other insights. These would then be codified and compared to generate analytical insights and generalizability. The start of each interview included a five-minute briefing period allowing for a review of the study's purpose and providing an

opportunity for the interviewee to ask questions or voice concerns. The researcher's approach to the interview process entailed probing for the context and meaning of the interviewee's responses to questions. This approach formed the most frequent fact-finding composition, and it is the most common technique used in semi-structured interviews (Campbell et al., 2013; Spradley, 2016). Therefore, the method of questioning was organized in succession and mechanistically probed between generalizable questions and more technically specific ones about the phenomenon. Additionally, the codification of the interview responses will be visualized in pie charts (see results section) to indicate the interviewees' awareness, aptitude, and intentions for using service robots in their business.

The interview consists of 9 questions, 4 of which are yes or no type of questions, the remaining 5 are open answer questions. The opinions provided by the interviewees, as mentioned earlier, were coded, creating 2-4 categories of answers for each question from the interview. The interview will be presented in the table below, as well as the categories of answers. The keywords and statements used to create each of the categories will be discussed in this section as well, with the examples of interviewees' answers provided.

Table 4. Categories of interview questions

№	Questions:	Categories:
1	Have you ever heard of robotics being used in the hospitality industry?	1. Yes 2. No
2	Did you know that robot models are being constructed specifically for hospitality purposes?	1. Yes 2. No
3	Would you be comfortable coworking with a robot?	1. Yes 2. No
4	Why? (A follow-up question to the question №3)	Question №3 response – Yes: 1. Easy to interact with 2. Helpful assistance 3. Safety Question №3 response – No: 1. No interpersonal exchange 2. Safety
5	What do you think robotics could improve in the hospitality industry?	1. Efficiency 2. Low-value job replacement 3. I don't think robots can make improvements
6	What would be the disadvantages of maintaining a robot according to you?	1. Expensiveness 2. Compatibility 3. Programing 4. Repairing
7	What would it be if a robot could do something humans couldn't do?	1. Intelligence abilities 2. Physical abilities
8	What would be irreplaceable in human service?	1. Human touch 2. Intelligence 3. Social Engagement
9	Do you see robots being human assistants shortly?	1. Yes 2. No

When it comes to the categories' formation, each answer was codified into a category, according to statements or keywords mentioned by the interviewees. Thus, questions №1, 2, 3, and 9 will not need the categories' formation explanation, as those questions were only answered with positive or negative answers, e.g., yes or no.

Question №4, Why? (A follow-up question to the question №3) – As this question is a follow-up to question №3, the answers categories will be split into two branches, according to yes or no answers in question №3.

Question №3 response – Yes. This branch consists of three categories of answers:

1. Easy to interact with.
   This category includes the following statements: no personal discomfort or disagreements; no need to search for the personal approach; the human factors are absent in communication with a robot.
2. Helpful assistance.
   This category includes the following statements: robots could facilitate the functioning and increase the efficiency of work; robots could fulfill the mundane tasks which don't require a personal touch; robots could be seen as similar to computers or phones work equipment.
3. Safety.
   This category contains only one answer of its kind: "I believe robots would be safer in some ways compared to people, similar to self-driving cars".

Question №3 response – No. This branch consists of two categories of answers:

1. No interpersonal exchange.
   This category includes the following statements: it would be impossible to have a conversation with a robot; efficient communication is critical in the hospitality industry; lack of communication and personal touch.
2. Safety.
   This category contains only one answer of its kind: "Robotics could be hacked or malfunction at the workplace, which could lead to guests' data leak, or create additional complication for workers to deal with".

Question №5, What do you think robotics could improve in the hospitality industry? – This question includes three categories of answers:

1. Efficiency.
   This category includes the following statements: "robotics could speed up certain processes at the workplace, make them more precision; robots could solve problems with communication/language barriers; robots could be able to cover more work tasks in a shorter time compared to a single human employee".
2. Low-value job replacement.
   This category includes the following statements: robots could take over most of the cleaning procedures, especially redundant physical activities, e.g., changing bed leaning, cleaning toilets, vacuuming floors; delivering materials within the hotel; robots could make the hospitality standard stability stronger, in the way of having the same good quality approach for low-value jobs.
3. I don't think robots could make improvements.
   This category contains only one answer of its kind: "I am not sure that robotics could make improvements or help. I do not like the idea".

Question №6, What would be the disadvantages of maintaining a robot according to you? – This question includes four categories of answers: expensiveness, compatibility, programing, repairing. Most of the interviewees pronounced the keywords for two or more categories at once. For this reason, the examples for all the four categories will be presented together: the disadvantage would be the expensiveness of its repair/maintenance; expensive, may not be perfectly compatible with a hotel infrastructure; technical problems, system errors, environment adaptation; Maintenance and programming would be the things to be concerned about.

Question №7, What would it be if a robot could do something humans couldn't do? – This question includes three categories of answers:

1. Intelligence abilities.
   This category includes the following statements: robots could be better in multifunctioning, compared to human workers, e.g., counting while talking; provide a faster service with more attention to detail; robots could take over long and tedious jobs in which it is preferable not to make mistakes; strictly following commands without thinking, as well as having no emotions at all.
2. Physical abilities.
   This category includes the following statements: robots could help humans with tasks that require reaching something high up or heavy lifting; robots would not need to take days off, holidays, or sick days; safety regulations improvement, like robots, couldn't experience panic in extreme situations, as well as they, would not be afraid of fire.

Question №8, What would be irreplaceable in human service? – This question includes three categories of answers:

1. Human touch.
   This category includes the following statements: a robot wouldn't be able to replace the "live" contact with another person, at least for now; robots wouldn't be able to imply personal problem solving, which involves empathy, intuition, and flexibility; smile, empathy, emotions, so-called "personal touch" would be irreplaceable.
2. Intelligence.
   This category includes the following statements: robots are not programmed to have psychological or moral training; adaptation to suddenly appeared situations; understanding of human concepts like money and hard work and what lies behind it.
3. Social Engagement.
   This category includes the following statements: emotional small talk, sometimes people want to have a small chit chat, this makes them more relaxed and open; personal opinion sometimes helps to resolve situations. Often guests ask for a place to visit, they also want to know whether it is good or not according to the worker's opinion.

5. Results and Discussion

5.1 MCDA results

The following section presents the MCDA comparison of the robot models presented in the literature review chapter, with a detailed discussion and justification on the rating provided. To calculate the efficiency of robots in hospitality, including all possibly accomplishable tasks, the results of each robot evaluation will be summarized and calculated as a percentage of 100% total of the presented tasks. Further evaluation will be based on the following rating:

- 0 (incapable of performing a task)
- 0.5 (moderately or lightly capable of performing a task)
- 1 (fully capable of performing a task)

Table 5. Front office/reception tasks

№	Task:	Importance of the task (weight):	NAO	Pepper	Jijo-2
1	Reception of the guests (casual conversation)	Medium (2)	1	1	1
2	Documentation keeping based on local state requirements (billing, guests' personal information)	High (3)	0.5	0.5	0.5
3	Organization of guest's luggage transportation assistance during check-in/check-out processes	Low (1)	1	1	1
4	General and additional information providing	Medium (2)	1	1	1
5	Implementation of guest wishes (taxi order, restaurant reservation)	Medium (2)	0.5	0.5	0.5
6	Guest's mail/parcel storage	Low (1)	1	1	1
7	Acceptance of personal guests' belongings to the deposit safes/storages	Low (1)	0	0	0
8	Calling emergency services (ambulance, firefighters, police)	High (3)	0	0	0
9	Room key issuing	Medium (2)	0.5	0	0
10	Analysis of rooms statuses and integrity	Medium (2)	0	0	0
11	Analysis of late/early check-ins/check-outs and voucher payments	Low (1)	0	0	0
12	Transmission of information about the hotel occupancy forecasting to heads of housekeeping and culinary branches	High (3)	0	0	0

The rating is further elaborated below:

Task №1 (Medium), Reception of the guests (casual conversation) – Based on the literature review, a conversation is one of the cornerstones features of all the three presented

robots – NAO, Pepper, and JIjo-2. Accordingly, the three presented models are completely capable of initiating and upholding a casual conversation with a guest.

Task №2 (High), Documentation keeping based on local state requirements (billing, guests' personal information) – Dividing the documentation keeping task into two – billing and guests' information records. Billing is currently an unsupported feature by all the introduced robot models, due to the necessity of the auxiliary equipment usage (e.g., computer, terminal, cashier). Furthermore, the guest's information recording is implementable by all presented models. However, the success of the function would still depend on the modification of the questions templates, according to the required information acknowledgment. Thus, neither of the presented robots would be able to write the information down for further processing.

Task №3 (Low), Organization of guest's luggage transportation assistance during check-in/check-out processes – Initially, luggage transportation assistance is the responsibility of the lobby clerk – bellman (Bocho et al., 2006). Therefore, the luggage transportation would only require the robots to give a verbal signal to the bellman to take care of the request. This allows all three models to manage the presented task.

Task №4 (Medium), General and additional information providing – Same as Task №1, all the presented robots can conduct a conversation, as well as provide available information on the guests' request.

Task №5 (Medium), Implementation of guest wishes (taxi order, restaurant reservation) – The guest's wishes implementation would in any way require the robot to be able to communicate through a phone or via email. Communication between the front office and the rest of the hotel branches happens via phone or email, the same as services outside a hotel. As this task requires both speech ability and auxiliary equipment usage (e.g., phone, computer), the presented robots would only be able to fulfill 50% of the task, which would be the talking process.

Task №6 (Low), Guest's mail/parcel storage – The robots only must be aware of the mail or parcel availability. In cases the mail was requested by the guest, a robot would have to notify the bellman, who would then hand it to the guest. All three robots can do so.

Task №7 (Low), Acceptance of personal guests' belongings to the deposit safes/storages – The storage of guests' belongings in the deposit safes doesn't only require paper records to be completed, but also physical involvement. The robot itself would have to input the item into the deposit safe and lock it. Unfortunately, none of the presented robots would be capable of taking care of both parts of the task. According to the discussion earlier, presented robots could not provide any paper records or operate auxiliary equipment.

Task №8 (High), Calling emergency services (ambulance, firefighters, police) – In cases of emergencies in a hotel, only a qualified worker could proceed with contacting emergency services, according to the proper standard. Any of the presented robots had been classified for such an action.

Task №9 (Medium), Room key issuing – Depending on the type of the key, room key issuing could require a) encoding a card key, b) reaching out to the regular key and then issuing.

Task №10 (Medium), Analysis of rooms statuses and integrity – Analysis of the rooms statuses and integrity would require the robots to be able to interact with the chosen hotel management software, which contains all needed information about the rooms, their statuses, and integrity. Framing this as auxiliary equipment usage, any of the presented robots would be able to complete the task.

Task №11 (Low), Analysis of late/early check-ins/check-outs and voucher payments – Same as Task №10, analysis of late/early check-ins/check-outs and voucher payments would require hotel management software usage. Rooms status analysis is essential for late/early check-ins/check-outs allowance. As well as software usage is needed for voucher billing.

Task №12 (High), Transmission of information about the hotel occupancy forecasting to heads of housekeeping and culinary branches – Transmission of information about the hotel occupancy happens in the way of physical or digital report handover. For this the presented robots would have to be able to either print the report or transmit it via email, both tasks involve the auxiliary equipment usage, which is currently unsupported by the reviewed robot models.

As for the score's calculation, the table above contains the information which will be used for calculations below, such as the total number of tasks; tasks implement ability rating of the robot's capability, referred to in the calculations as "robot(s) evaluation rating"; the weight of the tasks referred as "the task(s) weight".

Calculation of the scores:
The Weighted Scoring Method calculation formula is – a(b)+c(d)=X
The interpretation would be – robot evaluation rating(the task weight)+ robot evaluation rating(the task weight)=the total score

The maximum achievable score calculation:
1(2)+1(3)+1(1)+1(2)+1(2)+1(1)+1(1)+1(3)+1(2)+1(2)+1(1)+1(3)=23
The maximum activable score will have corresponded to 100% in the following calculations.
The robot scoring:
NAO: 1(2)+0,5(3)+1(1)+1(2)+0,5(2)+1(1)+0,5(2)=9,5
Pepper: 1(2)+0,5(3)+1(1)+1(2)+0,5(2)+1(1)=8,5
Jijo-2: 1(2)+0,5(3)+1(1)+1(2)+0,5(2)+1(1)=8,5

The scores presented above are the final scores for each of the reviewed robots' evaluations, based on the Weighted Scoring Method. The scores were calculated using the robot evaluation rating and the task weight according to the Weighted Scoring Method calculation formula. Furthermore, those scores will be presented as a percent out of 100% for the following research convenience.

The percent's proportion will be now calculated:
The proportion calculation formula is – a/b=c/d; ad=bc
NAO: 23/100%=9,5/X; 23X=950; X=41%
Pepper: 23/100%=8,5/X; 23X=850; X=37%
Jijo-2: 23/100%=8,5/X; 23X=850; X=37%
The scores presented above are the proportional percentages calculated based on the robots' final scores. These results will be further elaborated in the following chapters.

Table 6. Bartender tasks

№	Task:	Importance of the task (weight):	Bartender Robot	Barney Bar
1	Everyday bar setup preparation	Medium (2)	0	1
2	Procurement of the needed raw materials and beverages	High (3)	0	0
3	Working space and equipment cleanliness maintenance	High (3)	0	0.5
4	Cocktails and other beverages preparation and serving	High (3)	0.5	1
5	Finances and documentation about transactions keeping	High (3)	0	1
6	Tracking the amount of the raw materials and beverages sold	Medium (2)	0	0.5
7	Assortment provision according to the beverage menu	High (3)	0.5	1
8	Reception of the guests (casual conversation)	Medium (2)	1	1

The rating is further elaborated below:

Task №1 (Medium), Everyday bar setup preparation – Starting with an everyday bar setup, Barney Bar doesn't require a set up in advance. The necessary working equipment is united in the robot bar and the bottles are allocated in a convenient position by default. The only preparation the bar would require is the raw material replenishment. Furthermore, the Bartender robot is, unfortunately, incapable of preparing the working space for the day.

Task №2 (High), Procurement of the needed raw materials and beverages – None of the presented robots would be able to purchase the raw materials. This task would require not only the order placement and payment but also the acceptance of the delivery and further material management. Those tasks are currently unavailable for robot labour.

Task №3 (High), Working space and equipment cleanliness maintenance – When it comes to the workspace and equipment cleanliness maintenance, Bartender Robot is currently incapable of using any additional equipment, neither the robot is capable of cleaning any surfaces. Nevertheless, Barney Bar doesn't use any additional equipment, it's only adding ingredients to a glass or a cup, which is why there is no equipment the robot would require to be cleaned. Furthermore, the robot is incapable of general cleanliness maintenance, such as bar counter and surfaces cleaning, as well as the glassware and others.

Task №4 (High), Cocktails, and other beverages preparation and serving – Beverage's preparation and serving is completely supported by Barney Bar. The robot can mix cocktails, prepare coffee, pour beverages, etc. on its own, as well as serve them. Thus, Bartender Robot is only capable of serving bottled or prepared drinks, it cannot pour or prepare drinks on its own.

Task №5 (High), Finances and documentation about transactions keeping – Robot Bartender is unable to run financial transactions, nor keep track of them. Moreover, the Barney Bar has an order pad, which allows customers to choose and pay for beverages digitally, the

robot doesn't support cash payments. Furthermore, information about the payments is being automatically transferred to the master computer for further processing.

Task №6 (Medium), Tracking the amount of the raw materials and beverages sold – None of the presented robots were programmed to track the raw material usage. However, as a part of Barney Bar's ability to mix drinks, it does involve dosing, in this case, the robot would be capable of tracking the raw material usage if this ability would be further elaborated by the developers.

Task №7 (High), Assortment provision according to the beverage menu – Barney Bar can prepare all the learned in advance beverages, as well as a robot would be able to modify them if this was requested by a guest. According to the task Task №4, Robot Bartender is not capable of preparing any drinks by itself, however, the robot could serve any already prepared drinks. In this case, the robot would only be fulfilling 50% of the discussed task.

Task №8 (Medium), Reception of the guests (casual conversation) – Robot Bartender's primary function is to converse with one guest or more at the same time, the same as Barney Bar, which would even be capable of telling jokes. For this reason, both reviewed robots would be capable of conversing with the guests casually.

As for the score's calculation, the table above contains the information which will be used for calculations below, such as the total number of tasks; tasks implement ability rating of the robot's capability, referred to in the calculations as "robot(s) evaluation rating"; the weight of the tasks referred as "the task(s) weight".

Calculation of the scores:
The Weighted Scoring Method calculation formula is – a(b)+c(d)=X
The interpretation would be – robot evaluation rating(the task weight)+ robot evaluation rating(the task weight)=the total score

The maximum achievable score calculation:
1(2)+1(3)+1(3)+1(3)+1(3)+1(2)+1(3)+1(2)=21
The maximum activable score will have corresponded to 100% in the following calculations.
The robot scoring:
Robot Bartender: 0,5(3)+0,5(3)+1(2)=5
Barney Bar: 1(2)+0,5(3)+1(3)+1(3)+0,5(2)+1(3)+1(2)=15,5

The scores presented above are the final scores for each of the reviewed robots' evaluations, based on the Weighted Scoring Method. The scores were calculated using the robot evaluation rating and the task weight according to the Weighted Scoring Method calculation formula. Furthermore, those scores will be presented as a percent out of 100% for the following research convenience.

The percent's proportion will be now calculated:
The proportion calculation formula is – a/b=c/d; ad=bc

Robot Bartender: 21/100%=5/X; 21X=500; X=24%
Barney Bar: 21/100%=15,5/X; 21X=1550; X=74%

The scores presented above are the proportional percentages calculated based on the robots' final scores. These results will be further elaborated in the following chapters.

Table 7. Housekeeping tasks

№	Task:	Importance of the task (weight):	Roomba	Housekeeping robot	Aeolus robot
1	Performing tasks and requests set by room inspector	High (3)	1	1	1
2	Maintaining cleanliness in rooms, working areas, and public places (e.g. corridors, lobbies, etc.), while not disturbing guests	High (3)	1	0.5	1
3	Adhering to rules related to bed linen and towels change, also refilling all washing liquids in bathrooms	High (3)	0	0.5	0
4	Careful usage of cleaning chemicals	High (3)	0	0.5	0
5	A brief check of all electronic devices in the rooms, to make sure that they function well	Low (1)	0	0	0
6	Making sure that nothing from the room equipment is broken	High (3)	0	0	0.5
7	Report on broken devises or equipment in rooms or corridors	High (3)	0	0	0
8	Guests' wishes, and remarks should be reported as well	Medium (2)	0	0	0
9	Looks after guests and guests' belongings safety, discreetly looks after people in corridors, and informs reception in a situation when regulations or policy wasn't respected by the guests	Medium (2)	0	0	0.5
10	Checks the room status right after guests left the room	High (3)	0	0	0
11	Packs used laundry for washing	Low (1)	0	1	1
12	Provides daily reports about cleaning	High (3)	0	0	0

The rating is further elaborated below:

Task №1 (High), Performing tasks and requests set by room inspector – All the presented robots have a limited range of doable tasks, thus, if the robots are only required to function according to their abilities, they will fulfill 100% of the task presented.

Task №2 (High), Maintaining cleanliness in rooms, working areas, and public places (e.g. corridors, lobbies, etc.), while not disturbing guests – As well as the Task №1, Roomba and Aeolus robots would be able to maintain cleanliness as much as their given abilities would allow, while not disturbing the guests. Thus, according to the literature review, a Housekeeping robot was stated to be only able to perform supplementary works, which would only include in-room cleaning assistance.

Task №3 (High), Adhering rules related to bed linen and towels change, also refilling all washing liquids in bathrooms – Housekeeping robot would be the only one from the reviewed robots who have a direct function related to the towels and bed linen change, excluding the washing materials refilling. However, the robot was designed to be only capable of picking up the dirty towels or bed linens from the floor and packing it, so they could be further transferred.

Task №4 (High), Careful usage of cleaning chemicals – Roomba and Aeolus robots do not have any direct functions related to cleaning chemicals usage. However, one of the Housekeeping robot's doable tasks is toilet cleaning, which would require cleaning chemicals usage. Unfortunately, the detailed process of the toilet cleaning process by the Housekeeping robot wasn't yet shared by the developers. This leaves it unknown whether the robot is careful with the cleaning materials or not.

Task №5 (Low), Brief check of all electronic devices in the rooms, to make sure that they function well – This task was not included in any of the reviewed robots' tasks lists, as the task can be done by a human employee without significant time consumption.

Task №6 (High), Making sure that nothing from the room equipment is broken – None of the reviewed robots poses a direct ability to fulfill this task. Thus, the Aeolus robot can carefully learn the environment it functions in, which could enable the robot to acknowledge broken equipment in a room.

Task №7 (High), Report on broken devices or equipment in rooms or corridors – None of the robots would be able to report on the broken devices or equipment, as this function wasn't yet included in the doable tasks of the reviewed robots.

Task №8 (Medium), Guests' wishes, and remarks should be reported as well – As well as Task №7, none of the robots were given the ability to speak or send information via reports, which is why this task is currently undoable.

Task №9 (Medium), Looks after guests and guests' belongings safety, discreetly looks after people in corridors, and informs reception in a situation when regulations or policy wasn't respected by the guests – Aeolus robot could look out for guests and their belongings or reporting disturbing behavior, due to robot's ability to perceive the surrounding environment in detail, as well as understanding when an individual needs help. However, those functions would have to be set up accordingly, and training to be done. The rest of the reviewed robots would be incapable of fulfilling the task.

Task №10 (High), Checks the room status right after guests left the room – as housekeeping is the only department that states room statuses (clean, dirty, inspected, etc.), workers should be able to report on the rooms they had attended. Unfortunately, none of the

reviewed robots would be able to fulfill this task, as the reporting requires auxiliary equipment usage, e.g. computer, which wouldn't be possible for the robots to use at the moment.

Task №11 (Low), Packs used laundry for washing – both Housekeeping and Aeolus robots would be able to fulfill this task. Housekeeping robot was designed to fulfill this particular task; thus, Aeolus robots can pick up objects from the floor and replace them as required. Furthermore, Roomba wouldn't be able to fulfill this task.

Task №12 (High), Provides daily reports about cleaning – as well as task №10, reporting on cleaning of the rooms would be impossible for the robots to do, as it would require computer users to enter the room statuses into the hotel computer system.

As for the score's calculation, the table above contains the information which will be used for calculations below, such as the total number of tasks; tasks implement ability rating of the robot's capability, referred to in the calculations as "robot(s) evaluation rating"; the weight of the tasks referred as "the task(s) weight".

Calculation of the scores:
The Weighted Scoring Method calculation formula is – a(b)+c(d)=X
The interpretation would be – robot evaluation rating(the task weight)+ robot evaluation rating(the task weight)=the total score

The maximum achievable score calculation:
1(3)+1(3)+1(3)+1(3)+1(1)+1(3)+1(3)+1(2) +1(2)+1(3)+1(1)+1(3)=30
The maximum activable score will have corresponded to 100% in the following calculations.
The robot scoring:
Roomba: 1(3)+1(3)=6
Housekeeping robot: 1(3)+0,5(3)+0,5(3)+5,0(3)+1(1)=8,5
Aeolus robot: 1(3)+1(3)+0,5(3)+5,0(2)+1(1)=9,5

The scores presented above are the final scores for each of the reviewed robots' evaluations, based on the Weighted Scoring Method. The scores were calculated using the robot evaluation rating and the task weight according to the Weighted Scoring Method calculation formula. Furthermore, those scores will be presented as a percent out of 100% for the following research convenience.

The percent's proportion will be now calculated:
The proportion calculation formula is – a/b=c/d; ad=bc

Roomba: 30/100%=6/X; 30X=600; X=20%
Housekeeping robot: 30/100%=8,5/X; 30X=850; X=28%
Aeolus robot: 30/100%=9,5/X; 30X=950; X=32%

The scores presented above are the proportional percentages calculated based on the robots' final scores. These results will be further elaborated in the following chapters.

6. Interview results

The interviews were conducted among twenty 5-star hotel managers from Front Office, Culinary, and Housekeeping departments.

№1 Have you ever heard of robotics being used in the hospitality industry?

This question is one of the questions which were conducted to identify awareness of the interviewees on the topic of robotics being used in the hospitality industry. Thus, 17 out of 20 interviewees answered this question with a positive response, which is 85% out of 100%. While the other 3 answered negatively – 15%. Therefore, the results indicate that most of the managers interviewed are aware of robotics being used in hospitality.

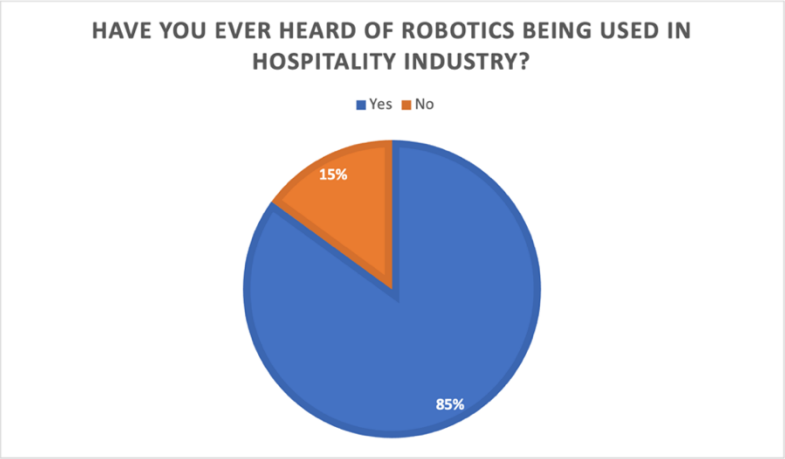

Figure 2. Interview question №1

№2 Did you know that robot models are being constructed specifically for hospitality purposes?

As well as question №1, question №2 was conducted to identify the awareness. However, it was also conducted to specify the knowledge on the topic. Also, among reviewed robots for general purposes, there are models which were constructed specifically for the hotel environment. Among the interviewees, 11 (55%) out of 20 were aware of that, the other 9 (45%) interviewees were not. Thus, more than half of the interviewees were aware that robots are being constructed specifically for the hotel environment.

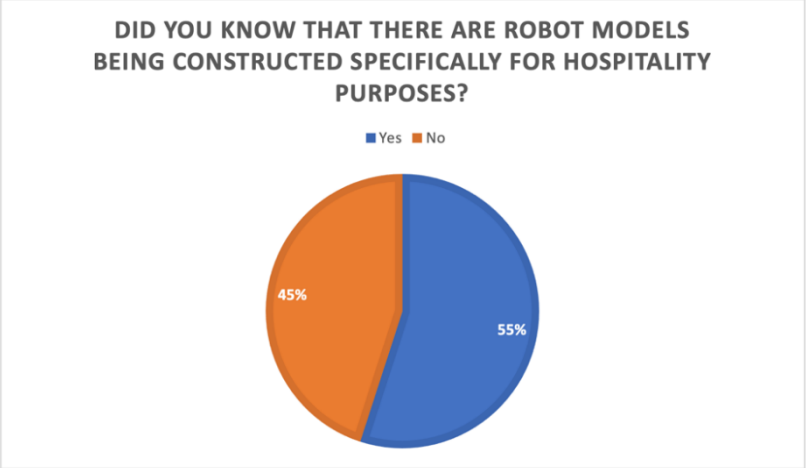

Figure 3. Interview question №2

№3 Would you be comfortable coworking with a robot?

This question was conducted to identify the aptitude. Thus, 14 (70%) of the interviewees would be positive about coworking with a robot, while the other 6 (30%) respond to the question negatively. Therefore, the biggest percentage of the managers interviewed would be comfortable coworking with a robot.

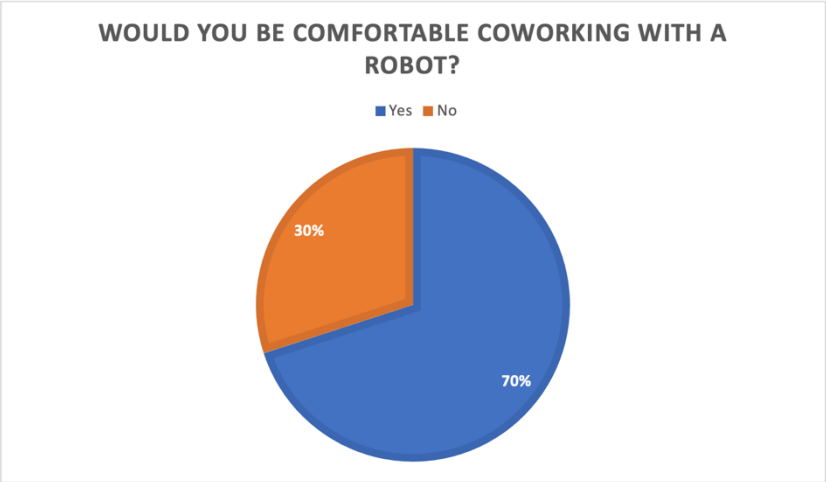

Figure 4. Interview question №3

№4 Why? (A follow-up question to the question №3)

This question is a follow-up to question №3, the answers categories will be split into two pie charts, according to yes or no answers in question №3.

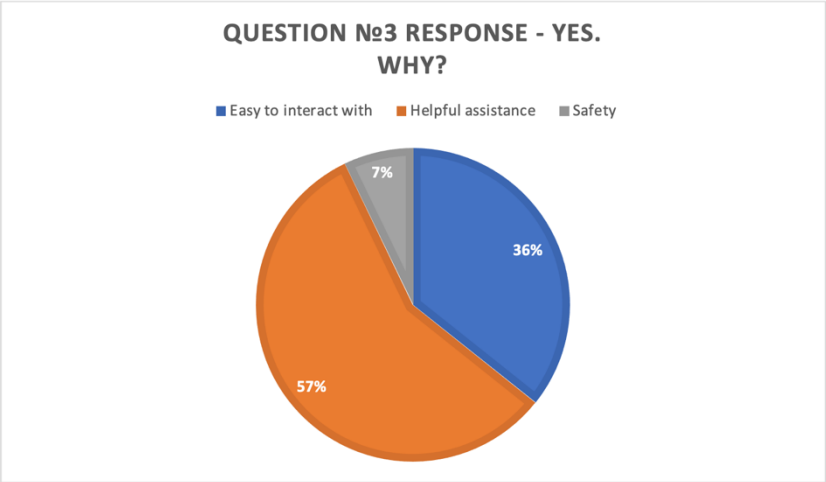

Figure 5. Interview question №4

The pie chart above represents the categorizations of the 11 interviewees previously responding "yes" to the question №3 – "Would you be comfortable coworking with a robot?". The question №4 – "Why?", follows with 3 categories of answers – "Easy to interact with", pronounced by 5 (36%) out of 11 interviewees; "Helpful assistance", pronounced by 8 interviewees (57%); "Safety" was only pronounced by 1 interviewee (7%). Thus, from the people who answered the question №3 positively, most of them did so because they believe coworking with a robot would be helpful.

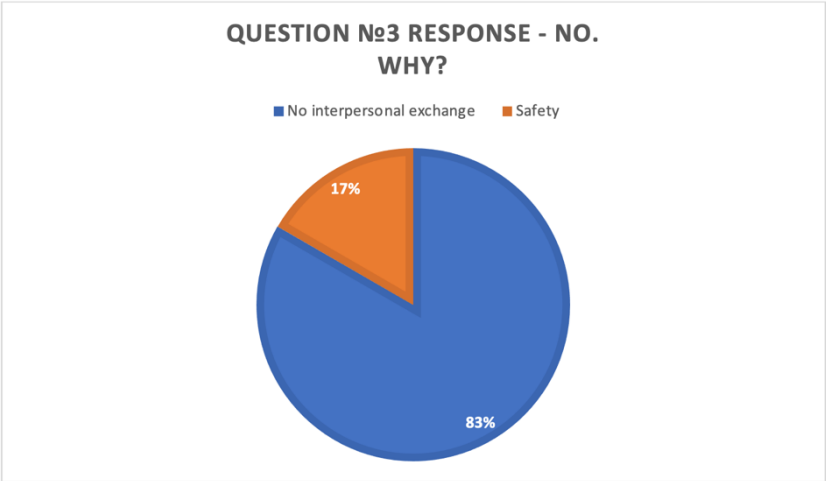

Figure 6. Interview question №4

The pie chart above represents the categorizations of the 9 interviewees previously responding "no" to the question №3 – "Would you be comfortable coworking with a robot?". The question №4 – "Why?", follows with 2 categories of answers – "No interpersonal exchange", pronounced by 5 interviewees out of 9 (83%); "Safety" was only pronounced by 1 interviewee (17%). Thereby, from the people who answered the question №3 negatively, most of them did so because they believe coworking with a robot would not have any interpersonal exchange.

№5 What do you think robotics could improve in the hospitality industry?

This question was conducted to identify the intentions of managers to use robotics in their departments. The acknowledgment of the benefits of implementing robotics in hospitality is the first step to be taken before considering the implementation itself.

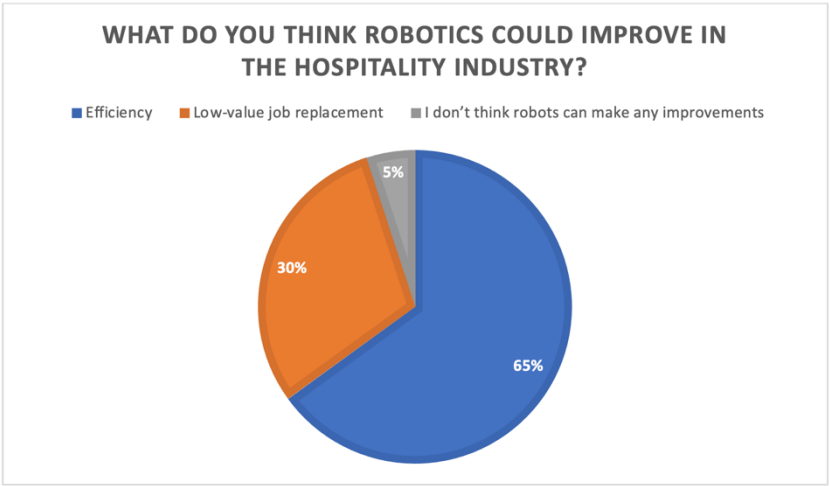

Figure 7. Interview question №5

The pie chart above consists of three categories of answers: efficiency, which reached 13 (65%) out of 20 interviewees responses; low-value job replacement, which reached 6 interviewees answers (30%); 1 of the interviewees (5%), stated that he or she doesn't support the idea of robotics being able to bring any improvements into the hospitality industry. Moreover, most of the interviewees believe, that robots would most improve efficiency.

№6 What would be the disadvantages of maintaining a robot according to you?

As well as the question №5, this question was conducted to identify the intentions of managers to use robotics in their departments. Thus, considering the disadvantages is also important in the primary research, before considering the implementation itself.

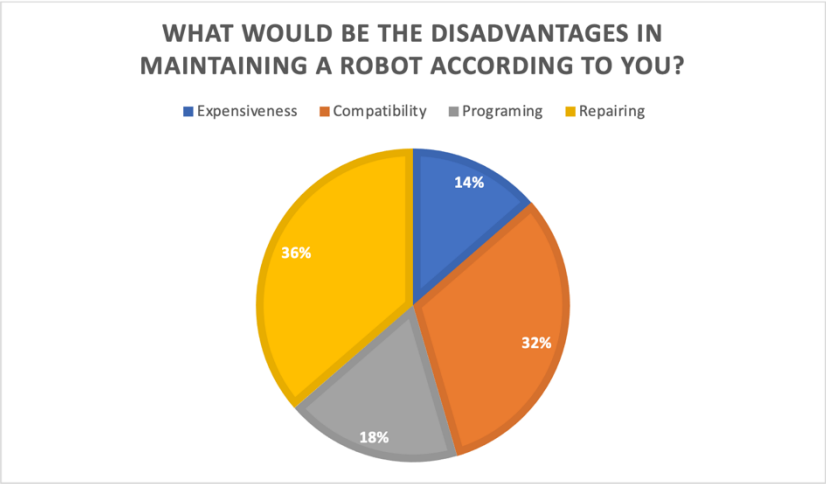

Figure 8. Interview question №6

The pie chart above consists of four categories of answers: expensiveness, which reached 3 (14%) out of 20 interviewees' responses; compatibility, which was pronounced by 7 interviewees (32%); programing, 4 answers of this kind were given (18%); repairing, 8 answers (32%). Thereby, the most common two disadvantages stated by the interviewees are repairing and compatibility.

№7 What would it be if a robot could do something human couldn't do?

This question was conducted to research the limitations of human abilities according to the managers interviewed.

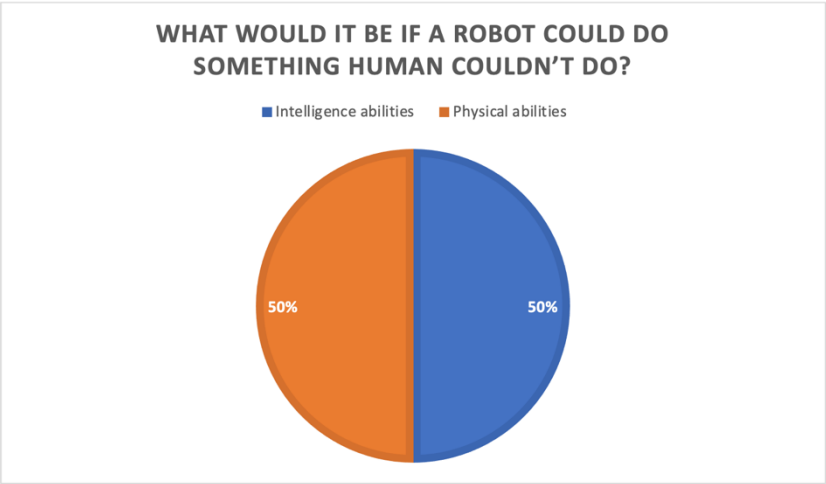

Figure 9. Interview question №7

The pie chart above consists of two categories of answers – intelligence abilities and physical abilities. Interestingly, the interviewees' opinions got divided into two equal categories on this question, with 10 statements per category.

№8 What would be irreplaceable in human service?

Same as the question №7, this question was conducted to research the limitations of robot abilities according to the managers interviewed.

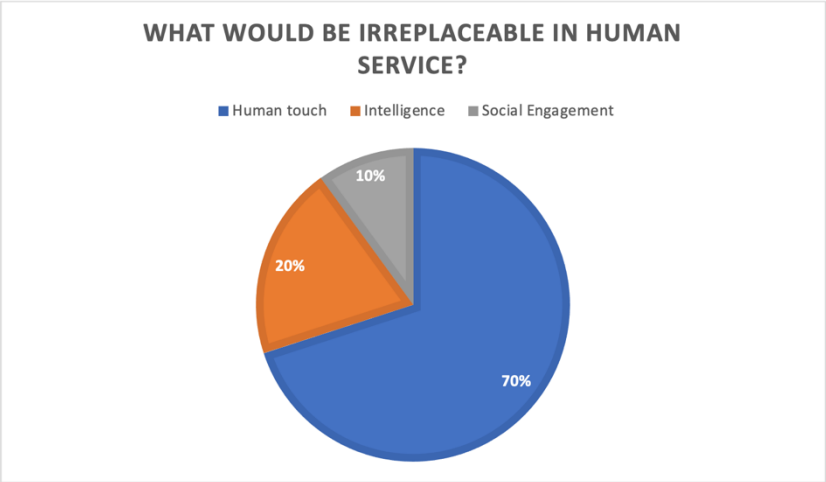

Figure 10. Interview question №8

The pie chart above consists of four categories of answers: human touch, this category was supported by 14 out of 20 interviewed managers (70%); intelligence, pronounced by 4 interviewees (20%); social engagement, 2 answers of this category were given (10%). Moreover, the biggest percentage of the interviewees believe that the most irreplaceable feature in human service is the human touch.

№9 Do you see robots being human assistants shortly?

This question was conducted to finalize the interview, concluding the main point of it.

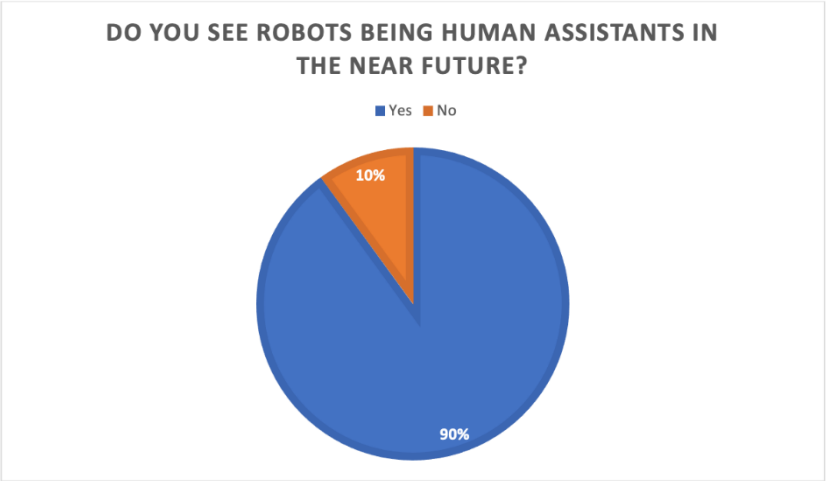

Figure 11. Interview question №9

The pie chart above consists of two categories of answers – positive and negative: the "yes" answer reached 18 out of 20 interviewees' answers (90%), while the "no" answer reached only 2 (10%). Which would mean that most of the managers interviewed would expect and/or support robotics implementation in the hospitality industry.

7. Recommendations

The recommendations were formulated to support the process of robotics becoming a helpful tool in the hospitality industry, based on the presented above research and calculations. As mentioned earlier in the interview question №6 – "the most common two disadvantages stated by the interviewees are maintenance and compatibility", as well as the "managerial standpoint" regarding "implementation of the robot workers in the hospitality industry will require beforehand preparation of the environment". This would include making working equipment and infrastructure compatable and accessible. Furthermore, at the moment robots are unable to access utility spaces such as stairs, even a doorstep could cause a robot problems. This means the area where a robot would be functioning should have smooth floors and track or tread accessible, similar to wheelchair accessibility. If a robot is required to travel between floors, the robot should have access to the elevator.

Moving forward, as the MCDA evaluation has shown, at the moment robotics are not able to fulfill 100% of the tasks given. Correspondingly, when designing the work structure and tasks assignment, robots should be assigned to the tasks in the first place, as they have limited abilities. Afterward assigning the rest of the tasks to the human employees. This way it will be possible to employ a maximum of the robot's capabilities while leaving tasks requiring a "human touch" for the human workers.

Furthermore, training for the human employees will be needed. As the interview analysis has shown, managers are not quite aware of what robots are presently capable of. Following back to the interview question №4 – "From the people who answered the question №3 negatively, most of them did so because they believe coworking with a robot would not have any interpersonal exchange". This is not completely true, a personal exchange wouldn't be possible as robots do not have a personality. However, a conversation could be done with no problem. Following back to the NAO technical overview – "*NAO* is a robot skilled with surrounding environment perception, human speech recognition, gesture, and body language production", which would be a lot similar to the way people perceive information and express their thoughts. As well as NAO robots were tested with a group of children in the kindergarten, being able to interact with kids in a very human-like manner. Therefore, the employees would have to get familiar with the robot's instructions beforehand, as it would be done with any new equipment or tool at the workplace.

Talking about technical issues while robot functioning. As mentioned earlier in the "managerial standpoint" section – "Robot maintenance could cause redundant expenses, including a need for an around-the-clock robot technician". As well as in interview question №6 – "the most common two disadvantages stated by the interviewees are repairing and compatibility". Therefore, the robots would indeed require technicians at all times when the robot is being used. As if the robot would undergo an error or a malfunction while working, it would distract other workers from their responsibilities, creating a lot of hustle and bustle, not even guaranteeing the error being solved by the hotel workers.

Finally, human employees should report not only on the errors and malfunctions but on the routine as well. As the robot needs to be as efficient as people in the tasks allocated for them. Human employees would have to supervise the robot(s), to maximize their efficiency. This wouldn't have to be done for as long as the robot is implied, but for the testing period most importantly.

8. Conclusion

The research presented suggests that the use of robots in the hospitality industry is still in it's infant stages, primarly due to human misunderstandings about how the robots can be implemented into traditional human roles. Indeed, robots of different physical appearances and skills have been developed for the hospitality industry, yet the results of this thesis show that the hospitality industry is not yet developed enough to actually implementing robotic assistance in the day-to-day operation of hotels. A gap exists between the human understanding/awareness of how robots can be implemented into their working environment. Additionally, it can be said that some hotel service staff who are dependent the existing infrastructure and know-how current in the hospitality industry, may in fact be resistant to the idea of having robots in their work-place.

The thesis has contributed to the literature domain of robot labor in the hospitality sector, which at present has not deeply examined the practical and socio-economic issues surrounding the global shift towards the automation of service industries. Future research should focus on the role of automation, particularly the infrastructure that would be needed to implement it. This approach could include examination of machine learning in artificial intelligence for robots in services roles, the socioeconomic dimensions associated with the replacement of menial hotel tasks with robots and the emergence of new jobs centered around the maintenance of robots and their infrastructure. Furthermore, research should be focused on the education and awareness of service industry personnel with regard to the utility of robots in their work-spaces and their changing roles in a hyper-sophisticated society.

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