Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 64 (2022) 6–13

Transportation Research Procedia

www.elsevier.com/locate/procedia

International Scientific Conference „The Science and Development of Transport - Znanost i razvitak prometa

Chatbot for training and assisting operators in inspecting containers in seaports

Silvia Colabianchi[a], Margherita Bernabei[a,*], Francesco Costantino[a]

[a]*Department of Mechanical and Aerospace Engineering, University of Rome "Sapienza", Via Eudossiana 18, Rome, 00184, Italy*

Abstract

The paper presents the chatbot applicability for the health and safety of workers in the container transportation context. Starting from a literature review of risks and hazardous activities in sea container terminals, the paper underlines the need of innovative systems to ensure the lowest level of risks for labours. An analysis of the 4.0 technologies solutions in sea container terminals shows the lack of empirical application of chatbots in such a context. Focus is given to the current chatbot applications, and on the conceptual methodology for the chatbot design, defining five models and presenting a taxonomy for the chatbot feature definition. A case study shows the possible application of the conceptual methodology and the taxonomy, introducing the Popeye chatbot, consisting of ~~a~~ voice service, spoken language understanding component and an image processing app, to cope with the hazards in the process of examining freight and containers in dock areas. The main application of Popeye is the training of new employees involved in container safety-critical quality inspection and controls operations.

Keywords: Conversational agents; container examination; voice assistant; conversational AI.

1. Introduction

Sea transport is crucial in the global economy, accounting for almost 90 per cent of global freight transport. (Jiang et al., 2020). Maritime ports represent cornerstones of logistics, supply chains and transport systems (Mohd Salleh et

* Corresponding author.
E-mail address: margherita.bernabei@uniroma1.it

10.1016/j.trpro.2022.09.002

al., 2021). Given the extent and prominence of this field, the issue of operator health and safety, and compliance with standards and procedures is even more critical. Worldwide, the transport of dangerous goods amounts to 40 percent of all containers moved through seaports. The handling of hazardous cargo demands great attention, operational practices, proper planning, and training of the personnel involved. In the recent past, several injuries occurred in seaport areas. Specifically, data collected by INAIL (Italian National Institute for Insurance against Accidents at Work) in its report on accidents in the maritime sector in 2019 reported 58 accidents (27 fatal and 31 serious) closely related to seaport operations (INAIL, 2019). Moreover, it is reported that workers who are injured are mainly cargo handling and warehouse operators (32.9%). Other accidents involved fires, explosions and oil spills that resulted in many injuries, such as human deaths and environmental damages (Jiang et al., 2020; Rostamabadi et al., 2019). Furthermore, the human factor is a major investigative factor in seaport safety events, as errors and violations prove to be the main causal factor in accidents (Khan et al., 2022). Those topics forced researchers to focalise on the security of dangerous cargo in the seaport and maritime context even more (Rostamabadi et al., 2019). The Fourth Industrial Revolution's enabling technologies represent great potential in this respect (Constantinos I. Chlomoudis et al., 2016), potentially resulting in increased health and safety for the operators employed therein, reducing risks and supporting skill-based, decision-based and perception-based activities (Khan et al., 2022), even if some cybersecurity issue arises (Annarelli et al., 2022). Many 4.0 technologies consolidated in this field, with different goals and with different level of operator involvement (Costantino et al., 2021). Despite this, to the best of authors' knowledge there is insufficient literature in the context of implementation of chatbots and virtual assistants in container terminals. Such a technology might be very hopeful in this domain, promising pervasive and easy access to information, applications and physical equipment, providing an appropriate tool for human-centric approaches (Gartler & Schmidt, 2021). The research purpose is to evaluate the possibility of using chatbots to support activities in the container terminals operations and then suggest a methodological design for them, to ensure proper operations and an increased degree of safety for operators. The paper aims to answer the following Research Questions. (RQs):

- RQ1. Can chatbot be a 4.0 smart tool to increase the health and safety of the operators in the container transportation context, specifically at sea container terminals?
- RQ2. How to implement this chatbot?

To answer the RQs, a literature review is conducted with a threefold objective: to investigate which activities require formalized procedures as most risky, and the consequent health and safety risks for operators working in sea container terminals. The analysis of the main 4.0 technologies implemented in this field to date investigates whether chatbots find applications or not. After that the chatbot applications are recognised as relevant, and the research presents a wide range of applications of chatbots. The study of these applications leads to a conceptual methodology, and the presentation of a taxonomy, as useful tools to implement a chatbot for health and safety in maritime transportation. A case study tests and validates in laboratory the chatbot application.

2. Literature Review

A broad range of operations is conducted in sea container terminals: passenger and cargo handling; oil and chemical storing; vehicle storing and transit; ship, truck, and train movement, etc. As a result of this high number of activities, seaports play a key role for in the economy, as well as representing a hazard, where personal injuries can occur (Constantinos I. Chlomoudis et al., 2016). Specifically, Pallis (2017) defined a taxonomy of risks in sea container terminals, made up of five risk categories: human, machinery, environment, security, and natural. Along with this taxonomy, general cargo controls, particularly at container terminals and storage facilities, present a variety of hazards (Berle et al., 2011). Existing guidelines are mostly for the external examination of containers and the internal inspection and inspection of cargo containers and vehicles. Maritime container shipping companies introduced many 4.0 technologies to improve performance and avoid risks (Sanchez-Gonzalez et al., 2022). An intelligent system exploiting the Industrial Internet of Things and Digital Twin technologies enables real-time monitoring of safety at work and provides real-time cyber-physical places for data tracking and visualisation (Zhan et al., 2022). Digital Twin and simulation also facilitate container-based workflow execution system since it consists of many tasks with precedence constraints (F. Li et al., 2022). When considering the store and transport of solid waste, e-smart robotics decrease possible environmental and health threats caused by faulty transport and harvesting (Kumar & Verma, 2022). Augmented reality-based inspection trains operators by simulating the procedure for cargo transportation, that is a labor-intensive activity (Yi et al., 2022). Virtual Reality allows simulating and assessing both automatic and semi-automatic cargo and cab operations, studying the ergonomics of the human operator inside the narrow space (Ottogalli et al., 2021). Other 4.0 solutions avoid risks arising from cyberattacks in the end-to-end process chain (Annarelli et al., 2022). An intelligent chatbot is a communication tool capable of interacting in natural language (Trappey et al., 2022). Considering current tendencies in terms of Artificial Intelligence this solution enhances Human-Robot Interaction (C. Li et al., 2021) offering easy access to information, applications and physical devices (Gartler & Schmidt, 2021). The main advantages include centralised access, customisation, empowerment and mentoring, hands-free and eyes-free user experiences, flexible support, multi-type interface assistance, continuous availability and quickness (Gartler & Schmidt, 2021). A chatbot can also enable voice interaction with dashboards for data visualization, and actively reminds relevant personnel to expedite data collection (Jwo et al., 2021). The number and variety of chatbots strongly increased in the last couple of years (Zumstein & Hundertmark, 2017). The virtual assistant research field is spreading strongly, mainly into an health direction (Davis et al., 2020). Manufacturing applications of chatbots presents solutions for the training on-the-job (Lakshmi Chandana et al., 2022) and assist workers to gain the knowledge they need to stay relevant and be competitive (C. Li et al., 2022). Specialized chatbots arise to handle a variety of complex activities, such as assembly tasks (Chen et al., 2021), order processing, and production execution (C. Li et al., 2021); some chatbots applications in transportation improve the delivery anytime, automate public transport information services (Kuberkar & Singhal, 2020), and add methods for interactive ticket purchase (Zumstein & Hundertmark, 2017). Concerning the maritime sector, some solutions developed have focused on vessels traffic control and safety (Choe, 2017; SHIP TECHNOLOGY, 2021) or a remote maritime support through augmented reality (CSN, 2020). However, to the best of author knowledge there is insufficient application of chatbots in container terminals. However, the features and implementation goals highlight the potential to support operators in risky activities at sea container terminals. Actually, such technologies established thanks to their social influence and anthropomorphism, ability to facilitate operations, even by conveying trust to the people they interface with (Kuberkar & Singhal, 2020).

3. Chatbot conceptual design methodology and case study

In this research the authors have developed an innovative cutting-edge chatbot for the training of new employees involved in container safety critical quality inspection and goods' controls operations (e.g., explosive materials and harmful substances control, missing parts control, etc.), named Popeye. This tool aims to be a proactive chatbot that helps operators identify all the risks linked to the process of examining freight and containers. The safety training will be directly on the job by adapting itself to the user's skill level. The chatbot follows the operators during the learning phase, explaining each task. In this context, digital assistant technology is perfectly positioned by providing the ability to develop training directly in the workplace. In addition, the operator can make all requests simply using natural language, without feeling a sense of embarrassment, and be quickly assisted and supported by the chatbot (McTear, 2020). Finally, the advantage of chatbots lies in the fact that they can be used during all operations as support tools since they make it possible for the operator to have hands and eyes-free. In section 3.1, we firstly present the chatbot design architecture modules as derived by the analysis of the papers in the literature review, then all the features' dimensions to select to characterize and thus implement the chatbot. Finally, the case study is described, the optimal dimensions for its development are chosen, and a sample conversation between a new employee and chatbot is proposed.

3.1. Chatbot Architecture

A chatbot architecture consists of five modules: Speech to Text (STT), Natural Language Understanding (NLU), Dialog Manager (DM), Natural Language Generation (NLG), and Text-To-Speech (TTS). The Speech to Text module capture and transcribe in text format the vocal input given by the operator. A variety of text to speech Application Programming Interfaces (APIs) can be employed to power chatbots. Most of them are based on Deep Neural Networks (Greff et al., 2017) and Hidden Markov Models (Ning et al., 2019). Natural Language Understanding is the process of comprehension of the structure and meaning of human language by machines (McTear, 2020). The process of text analysis starts with the use of Natural Language Processing techniques and continues with user intent classification and slot-filling. The Dialog Manager is the core module and manages the conversation with the user to achieve the objective expressed and execute the actions requested. The natural language generation module is responsible for generating the response text based on the decision made by the DM (Harms et al., 2019). The most appropriate response is generated based on three different models which differ in the level of artificial intelligence used: Rule-based, Retrieval, and Generative model. The text to speech module is the last module that converts text generated by the NLG into output in speech format (Ning et al., 2019). As shown in Figure 1, the architecture is grounded on a principle of close collaboration between modules that, while being independent, operate in synergy.

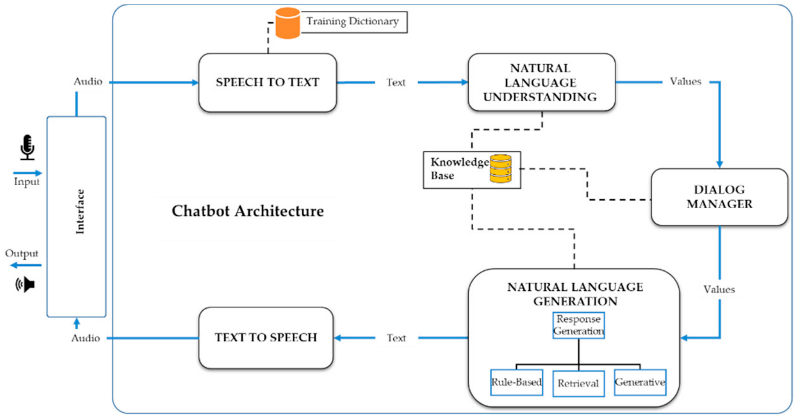

Fig. 1. Chatbot Architecture

3.2. Chatbot Characteristics

The majority of virtual assistants may be divided into two categories: open domain and closed domain. Our chatbot is designed as a closed domain chatbot since its main objective is to train and support an operator on a set of specific tasks. For the definition of the dimensions and characteristics that a chatbot should have we will refer to the taxonomy developed by Nißen et al. (2022). Their research developed a taxonomy of design characteristics for domain-specific virtual agent following a structured methodology that considered 103 real-world chatbots. The design taxonomy identifies three layers of analysis perspective: i) 12 dimensions related to chatbot profile, appearance, and intelligence; ii) 7 dimensions focused on chatbot-user interaction perspective; iii) 3 dimensions related to user perspective. Each dimension requires the developer to consider which is the best feature to be included in the chatbot for the best fulfilment of the objective. The taxonomy includes dimensions such as: time horizon, frequency and number of interactions, role, and communication style, chatbot personality, service integration, motivation and technicalities.

3.3. Case study: a safety training on the job chatbot

The case study conducted for this research is based on the process of examining containers in dock areas. Docks are among the most dangerous places for operators. According to the guidance given in the SAMANCTA database, among the most common hazards linked to the examining of containers are: *"the moving of vessels, overhead cranes and container-lifting machinery, hazardous substances, slippery surfaces, tripping hazards and heavy machines"* (*Health and Safety: Safe Working in Docks and Freight Areas - SAMANCTA*, 2021). The training process is articulated into the following modules:

- *General advice*. This module focuses on those recommendations that apply to examining all types of vehicles. For example, the operator should never operate alone; the operator should remove any jewels, pendants, and bracelets; the operator must use appropriate Personal protective equipment (PPE) equipment etc.

- *Hazards linked to the external examination of containers*. This module trains the operator on the best practice and countermeasures necessary to handle hazards linked to examination underneath a container, examination on top of containers etc.
- *Hazards associated with opening and inspecting containers and freight-carrying vehicles on the inside.* This module trains the operator on hazards such as: hazardous goods, items falling out of poorly packaged consignments, an inspection of refrigerated containers without proper equipment, etc.
- *Other possible hazards which might be encountered in dock areas.* Categories of hazards analysed in the modules are tripping hazards, slippery surfaces, confined spaces, cold storage, pressurised containers, and working close to railway lines.

According to the Technology Readiness Levels (TRLs) method (NASA, 2012), our research and the application developed stands with levels 1-4 successfully achieved. In fact, the solution was researched, designed, developed and validated in laboratory environment. Next steps will involve the validation in relevant environment. The proposed Popeye consists of a voice service, spoken language understanding component and image processing app. The operator wearing a headset with a microphone can communicate with the chatbot via voice commands; if necessary, an app on a mobile device can be used to detect barcodes, QR codes and obtain extra information. The chatbot connection to the headset and mobile device uses specific API and microservices (e.g. Microsoft Bot Framework V4 for Hololens, or Dialogflow Essentials for smartphones). Popeye will have the architecture described in with a rule-based response generation. Indeed, the chatbot will look for the appropriate response in a pre-defined database. For a better answer, the bot will use a spoken language understanding based on NLP techniques and a term frequency-inverse document frequency (TF-IDF) similarity method based on computing occurrences and the importance of each term and define the response with the highest cosine similarity within the context.

Table 1. Chatbot characteristics

Layer	Perspective	Design Dimension	Design Characteristic selected
Chatbot	Temporal Profile	D1 Time horizon	Medium term
		D2 Frequency of interaction	Multiple times
		D3 Duration of interaction	Medium
		D4 Consecutiveness of interactions	Related
	Appearance	D5 Role	Expert
		D6 Primary communication style	Task Oriented
		D7 Avatar representation	Not present
	Intelligence	D8 Intelligence framework	Rule based
		D9 Intelligence quotient	Text understanding +
		D10 Personality adaptability	Principal self
		D11 Socio-Emotional behavior	Not present
		D12 Service Integration	External data
Chatbot-User	Interaction	D13 Front-end user interface	Collaboration tools
		D14 Communication modality	Text + voice
		D15 Interaction modality	Interactive
		D16 User assistance design	Reciprocal
		D17 Personalization	Adaptive
		D18 Additional human support	Yes
		D19 Gamification	Not gamified
User	Context	D20 Application domain	Business and Education
		D21 Motivation/purpose	Coaching
		D22 Collaboration goal	Goal-oriented

From a features perspective to be set in Popeye, it was necessary to analyse each dimension and define the optimal characteristics reported in Table 1. Popeye is technically defined as a business (D20), goal oriented (D22) coaching (D21) chatbot for training and supporting operators in inspecting containers in seaports. The typical maritime environment is highly ordered, and regulated, which has resulted in the development of a Rule based chatbot (D8), Task oriented (D6) and Expert (D5). Indeed, Popeye will train the operators on a set of specific tasks, presenting itself to the operators as an expert in each operation. In case of critical situations that cannot be managed directly by Popeye, the operator can request through the bot for additional human support (D18). The operator can query the bot by voice or text (D14, D15). All the information is collected from an external database (D12) which contains procedures, quality check sheets and safety measures. However, the Popeye will also be linked to the container shipping details database and will be able to extract information from barcodes or QR code detected through camera or collect images of damages detected (D9, D13). The leader of the conversation can be either the user or the chatbot (D10) depending on the expertise of the user. Moreover, Popeye will be able to tailor the discussion to the user's prior interactions and inputs (D17) which is a fundamental prerequisite when training on the job operators with different background and preparation (D17). The chatbot's time profile is therefore defined by the user-chatbot relationship's medium-term time horizon (D1). The relationship is characterized by the possibility of multiple occasions for interactions of medium duration (D2, D3, D4). Finally, it was not considered essential to introduce a personification of the chatbot through neither avatar representation (D7) nor through the introduction of a socio emotional behaviour (D11) that shows empathy of the chatbot towards the user. The introduction of gamification elements such as quizzes was also ruled out since the chatbot is focused on on-the-job training that will be verified directly and there is no need for other forms of verification (D19). Figure 2 shows a short possible conversation focusing on a specific training task scenario. The intent assessed here is the safe underneath examination of a container.

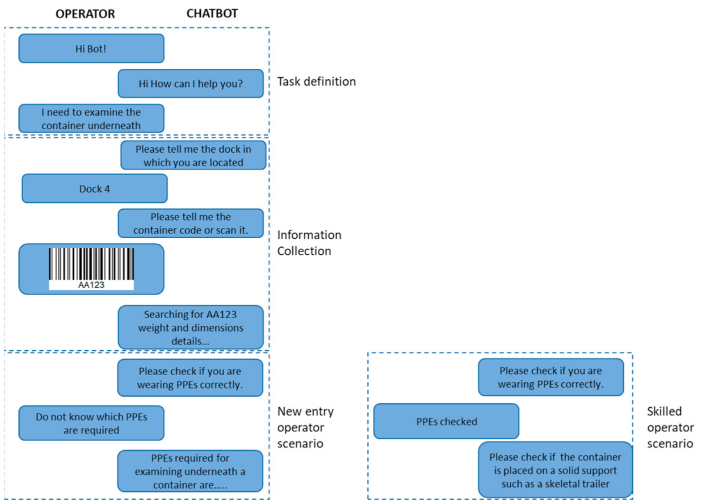

Fig. 2. Conversation

Popeye is queried by the user who is operating. The user awakens Popeye which starts the conversation by asking where he/she is located and which task he/she needs to perform. Once the operation is understood, the chatbot makes sure that the user is wearing the appropriate PPEs. If the operator does not know the PPEs required, he/she can ask for further information. Next, the user is asked to provide details of the container by dictating the code or scanning it. Once the size and weight of the object are understood, the chatbot communicates the appropriate security procedures to examine it from underneath. The chatbot checks with the user for the presence or absence of skeletal trailers and tractor units. If the user is not aware of some of these tools, additional explanation in the form of voice, video, or image can be requested from the chatbot and displayed on the mobile device provided to operators.

4. Conclusions

In a context where the need for health and safety is imperative, the applications of chatbot could increase training efficacy. Referring to RQs presented the following paper shows: i) How Popeye can improve the health and safety of operators in the container transportation context. In this context, procedures are complex and challenging to remember all in stressful, high-pressure situations. Popeye supports the operator by indicating the right procedure and assisting in performing procedures according to all safety instructions. ii) How to implement Popeye, by the design of its characteristics, and the way it interacts with the operator. The real-time interaction with a bot could strongly decrease the risk of accidents. The paper confirms this opportunity, underlining the lack of chatbot applications in maritime transportation. The development of a bot in such a context requires 5 modules of a conceptual methodology, as described in section 3.1. This conceptual design methodology and the taxonomy for implementation effectively drive the use of chatbot for the maritime transportation process. Currently, the new solution has been tested and validated in a laboratory environment, achieving TRL number 4. This showed a useful solution to be still tested in the real work environment. Specifically, future steps aim to achieve TRL 7 in the short term. The solution will be validated and demonstrated in a relevant environment, and the prototype system demonstrated in an operational environment. Also, the way to conduct operator training incorporating this new innovative technology will be defined. This might be an opportunity to test innovative, engaging, experiential, and on-the-job training practices. The more classic face-to-face learning is not exhaustive not encompassing safety training. As a result, it is not possible to make the operator experience all work-related hazards, some of which are explained only in theoretical form. Workers learn better with immersive experimentation (Coltey et al., 2021),which also provides a way to deal with new and emerging hazards related to employees' health and safety. The latter, needs to be considered to ensure informed and safe digital transformation (Costantino et al., 2021). Further future steps are to test Popeye in further seaport health and safety contexts (e.g., management of ship docking procedures).

References

Annarelli, A., Colabianchi, S., Nonino, F., & Palombi, G. (2022). The Effectiveness of Outsourcing Cybersecurity Practices: A Study of the Italian Context. *Lecture Notes in Networks and Systems*, *360 LNNS*, 17–31. https://doi.org/10.1007/978-3-030-89912-7_2

Berle, Ø., Asbjørnslett, B. E., & Rice, J. B. (2011). Formal Vulnerability Assessment of a maritime transportation system. *Reliability Engineering and System Safety*, *96*(6), 696–705. https://doi.org/10.1016/j.ress.2010.12.011

Chen, T. Y., Chiu, Y. C., Bi, N., & Tsai, R. T. H. (2021). Multi-modal Chatbot in Intelligent Manufacturing. *IEEE Access*. https://doi.org/10.1109/ACCESS.2021.3083518

Choe, S. (2017). *Developing Chatbot for Training Seafarers for better Understanding and Communication by Using Real VTS Data*.

Coltey, E., Tao, Y., Wang, T., Vassigh, S., Chen, S. C., & Shyu, M. L. (2021). Generalized Structure for Adaptable Immersive Learning Environments. *Proceedings - 2021 IEEE 22nd International Conference on Information Reuse and Integration for Data Science, IRI 2021*, 294–301. https://doi.org/10.1109/IRI51335.2021.00047

Constantinos I. Chlomoudis, Petros L. Pallis, & Ernestos S. Tzannatos. (2016). A Risk Assessment Methodology in Container Terminals: The Case Study of the Port Container Terminal of Thessalonica, Greece. *Journal of Traffic and Transportation Engineering*, *4*(5). https://doi.org/10.17265/2328-2142/2016.05.004

Costantino, F., Falegnami, A., Fedele, L., Bernabei, M., Stabile, S., & Bentivenga, R. (2021). New and Emerging Hazards for Health and Safety within Digitalized Manufacturing Systems. *Sustainability 2021, Vol. 13, Page 10948*, *13*(19), 10948. https://doi.org/10.3390/SU131910948

CSN. (2020). *Remote Maritime support through Smart Glasses and Augmented Reality |Cyprus Shipping News*. https://cyprusshippingnews.com/2020/09/14/remote-maritime-support-through-smart-glasses-and-augmented-reality/

Davis, C. R., Murphy, K. J., Curtis, R. G., & Maher, C. A. (2020). A process evaluation examining the performance, adherence, and acceptability of a physical activity and diet artificial intelligence virtual health assistant. *International Journal of Environmental Research and Public Health*, *17*(23), 1–14. https://doi.org/10.3390/ijerph17239137

Gartler, M., & Schmidt, B. (2021). Practical challenges of virtual assistants and voice interfaces in industrial applications. *Proceedings of the Annual Hawaii International Conference on System Sciences*, 4063–4072.

Greff, K., Srivastava, R. K., Koutnik, J., Steunebrink, B. R., & Schmidhuber, J. (2017). LSTM: A Search Space Odyssey. *IEEE Transactions on Neural Networks and Learning Systems*, *28*(10), 2222–2232. https://doi.org/10.1109/TNNLS.2016.2582924

Harms, J. G., Kucherbaev, P., Bozzon, A., & Houben, G. J. (2019). Approaches for dialog management in conversational agents. *IEEE Internet Computing*, *23*(2), 13–22. https://doi.org/10.1109/MIC.2018.2881519

Health and safety: Safe working in docks and freight areas - SAMANCTA. (2021). https://ec.europa.eu/taxation_customs/dds2/SAMANCTA/EN/Safety/WorkInDocksAndFreightAreas_EN.htm

INAIL. (2019). *PROBLEMATICHE DI SICUREZZA E DINAMICHE INFORTUNISTICHE IN AMBITO PORTUALE*. https://www.portskillsandsafety.co.uk/resources

Jiang, M., Lu, J., Yang, Z., & Li, J. (2020). Risk analysis of maritime accidents along the main route of the Maritime Silk Road: a Bayesian network approach. *Maritime Policy and Management*, *47*(6), 815–832. https://doi.org/10.1080/03088839.2020.1730010

Jwo, J. S., Lin, C. S., & Lee, C. H. (2021). An Interactive Dashboard Using a Virtual Assistant for Visualizing Smart Manufacturing. *Mobile Information Systems*, *2021*. https://doi.org/10.1155/2021/5578239

Khan, R. U., Yin, J., Mustafa, F. S., & Wang, S. (2022). Analyzing human factor involvement in sustainable hazardous cargo port operations. *Ocean Engineering*, *250*(August 2021), 111028. https://doi.org/10.1016/j.oceaneng.2022.111028

Kuberkar, S., & Singhal, T. K. (2020). Factors influencing adoption intention of ai powered chatbot for public transport services within a smart city. *International Journal on Emerging Technologies*, *11*(3), 948–958.

Kumar, A., & Verma, S. K. (2022). Design and development of e-smart robotics-based underground solid waste storage and transportation system. *Journal of Cleaner Production*, *343*(February), 130987. https://doi.org/10.1016/j.jclepro.2022.130987

Lakshmi Chandana, V., Ashita, G., Neha, K., Sravan Kumar, D., Suresh Babu, G., Krishna Kishore, Y., & Vijaya Bharathi, C. (2022). Voice-Enabled Virtual Assistant. *Sustainable Communication Networks and Application. Lecture Notes on Data Engineering and Communications Technologies*, 335–346.

Li, C., Hansen, A. K., Chrysostomou, D., Bogh, S., & Madsen, O. (2022). Bringing a Natural Language-enabled Virtual Assistant to Industrial Mobile Robots for Learning, Training and Assistance of Manufacturing Tasks. *2022 IEEE/SICE International Symposium on System Integration, SII 2022*, 238–243. https://doi.org/10.1109/SII52469.2022.9708757

Li, C., Park, J., Kim, H., & Chrysostomou, D. (2021). How can i help you? An intelligent virtual assistant for industrial robots. *ACM/IEEE International Conference on Human-Robot Interaction*, 220–224. https://doi.org/10.1145/3434074.3447163

Li, F., Tan, W. J., & Cai, W. (2022). A wholistic optimization of containerized workflow scheduling and deployment in the cloud–edge environment. *Simulation Modelling Practice and Theory*, *118*(March), 102521. https://doi.org/10.1016/j.simpat.2022.102521

McTear, M. (2020). Conversational AI: Dialogue Systems, Conversational Agents, and Chatbots. *Synthesis Lectures on Human Language Technologies*, *13*(3), 1–251. https://doi.org/10.2200/S01060ED1V01Y202010HLT048

Mohd Salleh, N. H., Selvaduray, M., Jeevan, J., Ngah, A. H., & Zailani, S. (2021). Adaptation of industrial revolution 4.0 in a seaport system. *Sustainability (Switzerland)*, *13*(19), 1–13. https://doi.org/10.3390/su131910667

NASA. (2012). *Technology Readiness Level | NASA*. https://www.nasa.gov/directorates/heo/scan/engineering/technology/technology_readiness_level

Ning, Y., He, S., Wu, Z., Xing, C., & Zhang, L. J. (2019). Review of deep learning based speech synthesis. *Applied Sciences (Switzerland)*, *9*(19). https://doi.org/10.3390/app9194050

Nißen, M., Selimi, D., Janssen, A., Cardona, D. R., Breitner, M. H., Kowatsch, T., & von Wangenheim, F. (2022). See you soon again, chatbot? A design taxonomy to characterize user-chatbot relationships with different time horizons. *Computers in Human Behavior*, *127*. https://doi.org/10.1016/j.chb.2021.107043

Ottogalli, K., Rosquete, D., Rojo, J., Amundarain, A., María Rodríguez, J., & Borro, D. (2021). Virtual reality simulation of human-robot coexistence for an aircraft final assembly line: process evaluation and ergonomics assessment. *International Journal of Computer Integrated Manufacturing*, *34*(9), 975–995. https://doi.org/10.1080/0951192X.2021.1946855

Pallis, P. L. (2017). Port Risk Management in Container Terminals. *Transportation Research Procedia*, *25*, 4411–4421. https://doi.org/10.1016/j.trpro.2017.05.337

Rostamabadi, A., Jahangiri, M., Zarei, E., Kamalinia, M., Banaee, S., & Samaei, M. R. (2019). Model for A Novel Fuzzy Bayesian Network-HFACS (FBN-HFACS) model for analyzing Human and Organizational Factors (HOFs) in process accidents. *Process Safety and Environmental Protection*, *132*, 59–72. https://doi.org/10.1016/j.psep.2019.08.012

Sanchez-Gonzalez, P. L., Díaz-Gutiérrez, D., & Núñez-Rivas, L. R. (2022). Digitalizing Maritime Containers Shipping Companies: Impacts on Their Processes. *Applied Sciences (Switzerland)*, *12*(5). https://doi.org/10.3390/app12052532

SHIP TECHNOLOGY. (2021). *ABS upgrades risk management platform with AI chatbots*. https://www.ship-technology.com/news/abs-platform-ai-chatbots/

Trappey, A. J. C., Trappey, C. V., Chao, M. H., Hong, N. J., & Wu, C. T. (2022). A vr-enabled chatbot supporting design and manufacturing of large and complex power transformers. *Electronics (Switzerland)*, *11*(1). https://doi.org/10.3390/electronics11010087

Yi, B., Sun, R., Long, L., Song, Y., & Zhang, Y. (2022). From coarse to fine: An augmented reality-based dynamic inspection method for visualized railway routing of freight cars. *Measurement Science and Technology*, *33*(5). https://doi.org/10.1088/1361-6501/ac3c1c

Zhan, X., Wu, W., Shen, L., Liao, W., Zhao, Z., & Xia, J. (2022). Industrial internet of things and unsupervised deep learning enabled real-time occupational safety monitoring in cold storage warehouse. *Safety Science*, *152*(March), 105766. https://doi.org/10.1016/j.ssci.2022.105766

Zumstein, D., & Hundertmark, S. (2017). Communicating and transacting with chatbots: Insights from public transport. *Proceedings of the International Conference on WWW/Internet 2017 and Applied Computing 2017*, *December*, 55–62.