Applicability of Artificial Intelligent Techniques for Effective Communication in Green Construction

K.I. Ridmika and Menaha Thayaparan
Department of Building Economics
University of Moratuwa
Sri Lanka
isuridmika@gmail.com, mthayaparan@uom.lk

Abstract

Even the green concept precisely addresses the environmental unfriendliness in the construction industry, its adaptation still has barriers and issues. Green buildings have often involved the implementation of different success factors by construction professionals such as designers, project managers, contractors and quantity surveyors in order to overcome the difficulties and to ensure success in the delivery of green buildings. For instance, integration in the project delivery process enables the project participants to interact seamlessly to achieve better sustainable outcomes. Greater communication among project participants, particularly through multiple communication means contribute to success in the delivery of green buildings. It is found that various techniques of Artificial Intelligence have effectively contributed to the modernising of the construction industry through more reliable, automated, self-modifying, time-saving, and cost-effective process in construction management. Hence, this paper intends to bring in literature synthesis addressing applicability of Artificial Intelligence techniques to enhance green construction through overcoming the barriers and issues in communication within green construction. Ultimately a conceptual framework is developed to understand the applicability of the AI in communication in green construction.

Keywords
Artificial Intelligence, Communication, Green Construction

Introduction
Even though the world is leading towards great achievements all the time in terms of physical development and facilitating the quality of life, it is questionable whether all kinds of living creatures are protected in this state of environment (Hossain and Ng 2019). The depletion of Ozon layer, ascending of global warming day by day, deforestation and adverse climatic changes have become huge environmental tragedies (Hussin et al. 2013). Construction industry performs a vital role in the global economy that contributes to the global GDP by 13% (Hossain and Ng 2019). Hence, it is becoming increasingly difficult to ignore the output of such a wide-spread industry throughout the world. Typically, it satisfies the need of building and infrastructure development to facilitate the necessities of human beings (Enshassi et al. 2014). Unfortunately, construction industry does not only play an important role in the global economy, but it also generates adverse consequences towards social and environmental aspects (Hussin et.al 2013). The construction activities influence the environment substantially across a wide range of off-site and on-site activities (Shen and Tam 2002). Accordingly, the construction activities negatively influence on environment through the mining of environmental resources such as fossil fuels and minerals; the growth in the use of generic resources such as soil, water, air and energy; the production of waste requiring land use for disposal; and contamination of the natural ecosystem with noise, odours, dust, vibrations, chemical and particulate pollutants, and solids (Shen and Tam 2002). In global scale, the construction industry is responsible for 40 per cent of energy consumption, 30 per cent of CO2 emissions and 40 per cent of total solid production waste (CRI 2014). The adverse impact created by the construction industry on the environment has been discussed and researched to suggest solutions to overcome (Hussin et.al 2013). The concept of green has directly addressed the environmental unfriendliness of the construction industry (Glavinich 2008). A green building can be identified as a building that in its design, construction, operation, maintenance, renovation and demolition minimise or eliminates adverse impacts, and can form and maximise positive impacts, on the climate and natural environment (Zuo and Zhao 2014).

According to Schwab (2017), the Industrial Revolution 4.0 changes the human life, their working procedure and the relationship. In recent decades, a rapid development of digital technology and the growth of big data can be identified

in the construction industry (Pan and Zhang 2021). Specifically, the implementation of Artificial Intelligence (AI) has acquired huge awareness, which attempts to furnish machines with human-like intelligent (Chen et al. 2008). AI is a section of science which manages assisting machines with discovering answers for complex issues in a more human-like design (Xiang et al. 2021). In general, AI entails taking aspects of human intelligence and applying them as algorithms in a computer-friendly manner (Chen et al. 2008). Simulated intelligence processes have had a huge impact on the development industry, resulting in a more dependable, automated, self-adjusting, efficient, and clever approach to development across the board. Various AI-related techniques can eventually reach key functions in automation, risk mitigation, high efficiency, digitalization, and computer vision. As a result, there is a lot of interest in using a variety of AI techniques in the construction industry to take advantage of the great opportunity of digital development for improved performance and profitability (Pan and Zhang 2021).

Even the green concept precisely addresses the environmental unfriendliness in the construction industry, still its adaptation has barriers and issues. A construction is not an outcome of a sole person but is executed by a number of different stakeholders (Jingxiao et al. 2019; Sarkis et al. 2012). Different success factors of each stakeholder are to be often incorporated to ensure a successful green construction (Jingxiao et al. 2019). Greater communication among project participants, particularly through multiple communication means contribute to success in the delivery of green buildings. Poor communication does have negative effects on green practice in each stage of a green project (Ying et al. 2012). The application of AI has been discussed in terms of the collaborative working environments (Pan and Zhang 2021). AI can create immense opportunities and lead in an ecosystem where virtual robots, voice assistants and robotic process automation (RPA). It will serve in collaboration with humans to maintain effective communications and operations (Oesterreich and Teuteberg 2016). When it comes to sustainability, Vinuesa et al. (2020) highlighted that AI can be used to conserve the environment through its capability of analysing large scale interconnected database to develop cooperate actions. Few studies have explored the value of sub area of AI on the provisions such as green building management and green architecture (Elshafei and Negm 2017). Hence, this study will investigate whether or to what extent the AI techniques can be incorporated for an effective communication to execute successful green project. Although the construction industry is well placed to embrace these technologies for competitive and operational advantage, there is a lag in the diffusion of the technologies in the industry (Vinuesa et al. 2020). Accordingly, this study will inspire the adaptation of AI techniques in construction industry. Further, this study is narrowed down to review the applicability of AI techniques for effective communication in green building project. As there is a dearth of significant research carried out on application of AI techniques for green construction, this research intends to focus on that knowledge area. Hence, this paper intends to bring in literature synthesis addressing applicability of Artificial Intelligence techniques to enhance green construction through overcoming the barriers and issues in communication within green construction. Ultimately a conceptual framework is developed to understand the applicability of the AI in communication in green construction.

Research Methodology

Integrative literature review was adopted as the research approach which allows to create initial or preliminary conceptualizations and theoretical models for emerging research topics. Integrative literature review tries to bring together insights and perceptions from different research territory rather than studying all published articles on particular research topic (Snyder, 2019). Figure 1 depicted the research process adapted in this study.

Figure 1. Research Process

Since this research aimed at several research areas; communication, green construction and artificial intelligence, integrative review approach was selected as most preferable when desigining the review. Accordingly, the literature were studied through the journals and conference publications under the search term of “communication in green construction, communciation and artificial intelligence, green construciton, artificial intellegnce in construction industry” in the database of google scholar. The conducting review was done by first reading abstracts to select the

articles that were appropriate. The selected papers were reviewed in details to extract the apllicable information which in tun was analysed and used to write up the literture review.

What is Green Construction?

Green construction is the flagship in the construction industry which focuses on environmental tragedy (Ahn et al. 2017). The concept of green within the business world emerged in the literature in 1980s and 1990s, having same background as the concepts that were adopted in businesses such as sustainability (Trandafilovic et al. 2017). Being green balances one base of sustainability as environmental health or economic vitality while sustainability focuses on three legs of its tripod as economic vitality, environmental health and social equity (Ernest et al. 2009). But being green has become a flagship of sustainable development because its accomplishment provides long term economic, environmental and social well-being (Ali and Nsairat, 2009). Green is a concept which amalgamates best environmental and business performances within an organisation, it as to be more sustainable, responsive to the society's environmental concerns, effective, competitive and attentive to the customers (Darko et al. 2018). Green building uses resources in more efficient way compared to conventional building and it makes healthy and productive environment for occupants as ultimate output (Waidyasekara and Fernando 2012). The spreading of green construction is changing the way construction professionals design and execute a project (Ahn and Pearce 2007). The depletion of Ozon layer, ascending of global warming day by day, deforestation and adverse climatic changes have become huge environmental tragedies (Hussin, Rahaman, and Memon, 2013). Most of the human activities directly or indirectly cause to these adverse effects (Enshassi, Kochendoerfer, and Rizq, 2014). The concept of green building is one of main strategy which has been practice to address this issue particularly in construction industry (Hussin et al. 2013).

Effective Communication as a Success Factor in Green Construction

Communication is fundamentally the exchanging of information to pass on a message, and effective communication transmits the message in such a way that the intended recipients receive and understand it (Zulch 2014). Success of a construction project depends incredibly on effective communication (Olanrewaju et al. 2017). Teamwork and project collaboration will also benefit from good communication (Li et al. 2011). Misunderstandings, delays, and problems can emerge because of poor communication in construction project (Zulch 2014). Inferable from the more noteworthy spotlight on satisfying green goals in a construction project, it is difficult to accomplish such goals with ineffective and less communication among the stakeholders (Hwang et al. 2013). The ability of project team members to accomplish tasks together is critical to the achievement of high performance and productivity of the green construction project. Within a green construction, t ought to be successfully communicated about the cost, time and quality as three of the four foundation factors on which the accomplishment of a green development project depends, trailed by scope (Kibert 2016). Because of this, communication is a strategic consideration in green construction projects (Li et al. 2011). Further, as green building construction required a more detailed design due to its complex technological characteristics, it required for greater efforts in communication and collaboration between project parties (Hwang et al. 2013).

Integrated processes and approaches are incorporated in planning, designing and constructing for a successful green construction (Elforgani et al. 2006). There are many different stakeholders, including architects, engineers, contractors, construction managers, owners, building occupants, building operators, and government agents in green construction (Hammond et al. 2019). All of stakeholder are required to pay full commitment towards ensuring integrated design and construction processes for a successful green construction (Jingxiao et al. 2019). Developing an innovative and effective green building solutions through a greater communication is a prominent success factor in successful green construction throughout the process (Elforgani et al. 2006; Kibert 2016). According to Robichaud and Anantatmula (2011), there are four stages in green construction namely feasibility, design, implementation and close out as shown in Table 1.

Table 1. Stages in Green Construction Process

Project Process	Approach
Stage 1 – Feasibility	
Project need assessment	Need a definition for the project (Ogunmakinde et al. 2017)
Project manager selection	Hire a competent green building consultant/project manager (Ogunmakinde et al. 2017; Robichaud and Anantatmula 2011)
Preliminary site analysis and plan	Finalize economic and ecological goals, consider site characteristics and weigh building needs against ecological issues (Ogunmakinde et al. 2017; Robichaud and Anantatmula 2011) A Green Certification checklist and documenting system is developed for the remaining portion of the feasibility stage (Agyekum et al. 2019)
Design charrette	Collaborative meeting with all key external stakeholders, including surrounding property owners and other community representatives which considers the functions namely design, architecture, building contractor, environmental engineer, real estate consultant, etc. (Valdes-Vasquez et al. 2014)
Final site selection	Select site based on stakeholder involvement including community input (Korchagina et al. 2013)
Stage 2 – Design	
Initial budget and schedule	Complete preconstruction estimates (Tsai et al. 2014) Estimate costs associated with specialized areas like green-building products (Tsai et al. 2014) An emphasis on life cycle costing, shifting focus from short-term return on investment to long-term gains from operational savings (Robichaud and Anantatmula 2011)
Zoning approval	Site will be planned by following feedback from design charrette and the from local government planners and other regulatory (Robichaud and Anantatmula 2011)
Design team selection	Usually, the core design team has already been selected by this time.
Construction document development	Because the integrated team has participated in the planning and design process, construction documents can be developed more efficiently and with little design modifications
Project bidding	Construction owners and the consultants must obtain accurate cost information for bid selection (Tsai et al. 2014)
Stage 3 - Implementation	
Contracting	Integrated development requires a different kind of client/ architect and client/contractor contract (Jingxiao et al. 2019)
Construction	Implement sustainable construction practices (Hwang et al. 2013) Periodic education and training sessions on green building (Hasan and Zhang 2016; Wimala et al. 2016) Sustainable requirements are reviewed with each subcontractor prior to commencing work (Ahn et al. 2017)
Inspections	Necessary inspections and tests for attaining green goals by supervision team (Raouf and Al-Ghamdi, 2020)
Green certification	Following up and documentation of achievements of sustainability benchmarks prescribed in Green Certification (Agyekum et al. 2019)
Stage 4 – Close Out	
Occupancy and operations	Commissioning requirements for green building technologies (Agyekum et al. 2019)

In feasibility stage, it is required a greater communication among the stakeholders to analyse the viability of the green construction project as depicted in Table 1. The design charrette creates and supports for a feasible action plan in green construction with all key participants. Incorporating a charrette at the beginning of a construction project is a solution to improve communication and exchanging ideas among a project's stakeholder group (Robichaud and Anantatmula 2011). Further, to select a competent project manager, the construction owners have to consider their experience and capabilities in executing green project (Jingxiao et al. 2019). Construction owners have to collect accurate cost

information to support bidding judgments in green construction as there are specified cost items such as carbon dioxide emission tax, green building materials, renewable energy sources etc. (Tsai et al. 2014). In the process of designing, implementation and also close out in green construction project, it it required to collect, store, analyse and interprete availble past data, real time data, relevant information from stakeholders and hindden data in construction site for a successful green project delivery (Robichaud and Anantatmula 2011). Accordingly, the green project may require particular and a more detailed communications analysis and plan to keep stakeholders informed throughout the project.

Artificial Intelligence (AI) in Communication

Expansion of digitisation and automation of the manufacturing environment together with a digital value chain to enable the communication between products and their environment and business stakeholders can be identified in Industry 4.0 (Gunkel 2012). The machines and software algorithms, capable of imitating human cognitive abilities will take over the human based content creation. This will lead to new way of generating, communicating and consuming data (Guzman and Lewis 2020). Nowadays, social networking platforms and personalized communication is getting more intelligent and advanced. In the near future, it is expected that the human emotions will be equally or will be contributed by machines (Jakesch, et al. 2019). Moreover, combined with virtual and augmented reality, self-learning systems or intelligent systems will be used in mass communication and personal communication (Guzman and Lewis 2020). Wiesenberg, Zerfass, and Moreno (2017) found that the implementation of big data and automation which are the technologies linked to the AI bring unique opportunities for strategic communication. Furthermore, Zerfass et al. (2020) studied initial insights on the application of AI in communication management. Particularly, AI techniques have capabilities to support the construction companies to reduce complexity and uncertainty, to enhance information exchange and communication between project stakeholders and thus to increase productivity and quality (Guzman and Lewis, 2020). The use of Augmented Reality (AR) can be used in effective communication mechanism in the construction industry due to there are huge hidden data in construction sites. Further to that, cloud- and BIM-based platforms or social media apps can efficiently improve collaboration and communication even across company borders as there is a number of stakeholders involved in each construction project (Oesterreich and Teuteberg, 2016).

Artificial Intelligence in Construction Industry

Artificial Intelligence is a branch of science which manages assisting machines which discover answers for complex issues in a more human-like way (Xiang et al. 2021). AI generally borrows the attributes from human intelligence and applies them as algorithms in a computer approachable way (Chen et al. 2008). AI techniques have created immense value in modernising the construction industry through more reliable, automated, self-modifying, time-saving, and cost-effective process in construction management (Pan and Zhang, 2021). The following AI applications have been studied for effective construction management. An early form of AI: Knowledge representation and reasoning adopt a symbolic representation of domain knowledge and pre-defined rules to build the knowledge-based system instead of complex algorithms or statistics (Abubakar et al. 2019). Therefore, computers can rationally interpret the available knowledge, facts, and beliefs from the real world, and then come up with a valid conclusion and facilitate logic rational decisions in a transparent and efficient manner (Chen et al. 2008). Another form of AI, information fusion can be performed to combine the extracted data from the construction site through sensors for better detection, inference, and characterization (Pan and Zhang, 2021). Further to that, the computer vision collects information through the equipment, like camera, unmanned aerial vehicles (UAVs), light detection and ranging (LiDAR) etc., and show non-contact and remote solutions for project monitoring (Rawai et al., 2013). As another important subfield of AI, Natural language processing (NLP) explore, and interpret language-related data through human- like natural language comprehension with computers (Olsson and Rexmyr, 2017). A lot of valuable knowledge in free text data may be unexplored in traditional manual studying of them. Hence, NLP is progressively applied instead of the tiresome human supervision over reading larger volume of textual information (Pan and Zhang 2021). Further to the same author, since the construction industry is information-intensive, NLP has the potentials in information management in construction industry. Another technique comes under AI; intelligent optimization investigates the optimal solution comparing various solution (Kong and Ma 2020). Intelligent optimization has been extensively used in the construction and engineering management, since its simple implementation, efficient computational time, robustness, and capability in global optima selection (Pan and Zhang 2021). Process mining is a logical discipline for finding, checking, and improving processes as they really are by extracting information from event logs promptly accessible in the information systems. As a result, it can provide transparent and fact-based insights from real event logs for better process monitoring and control in construction project (Pan and Zhang 2021). Smart robotics which is another form of AI, have been evolving rapidly to drive a wide range of semi- or fully autonomous construction applications (Kim et al. 2015).

Another technique in AI, virtual reality (VR) and augmented reality (AR) performs as the information visualization technology to realize more interactions between the physical and cyber worlds, where VR simulates the entire situation and AR integrates the information about the real entities with computer-generated images. VR/AR has been applied to simulate hazardous construction scenarios, which helps managers to easily recognize underlying dangers and issues in the working environment and then formulate reasonable plans and measures ahead of accidents in a visual and interactive way (Pan and Zhang 2021; Rawai et al. 2013). According to Hossain and Nadeem (2019), Artificial Intelligence of things (AIoT) which is another technique in AI stream, can collect real-time data about the operational status of the project through interconnected physical devices, like sensors, drones, 3D laser scanner, wearable and mobile devices, radio frequency identification devices (RFID), which are attached to construction resources. Further, the AI technique of digital twin which is a realization of the cyber-physical system for visualization, modelling, simulation, analysing, predicting, and optimizing can provide immediate solutions to guide the realistic process and make it adapt to the changeable environment in construction industry (Pan and Zhang 2021). Further to the same author, the emerging technology called 4D printing adds the fourth dimension from time into 3D printing, enabling the 3D printed objects to change their shape and behaviour over time in response to external inducements such as light and temperature etc.. Another nascent technology called blockchain is a powerful shared global infrastructure, which is originally utilized for simplifying and securing transactions among parties (Perera et al. 2020). Basically, the concept of blockchain can be explained as a verified chain with blocks of information, and each block embodies data associated with processes in a trusted environment. Therefore, the potential of blockchain in construction is significant since the blockchain builds a distributed ledger, all users of the network can access the stored digital information concurrently (Pan and Zhang 2021; Perera et al. 2020).

Application of Artificial Intelligence for Effective Communication in Green Construction

The findings through the comprehensive literature review for the areas mentioned in the objectives for the Artificial Intelligence in communication in green construction, are mapped together using a conceptual framework as presented in Figure 2. The framework can be applied to find out the relationship between Artificial Intelligence application on effective communication in green Construction.

The conceptual framework in Figure 2 shows how application of Artificial Intelligence assists in effective communication in different stages in the green construction project. Good communication is important in green construction (International Labour Office, 2011). Misunderstandings, delays, and problems can arise because of poor communication. Effective communication improves the teamwork and project collaboration which are highly impactive to successful green construction (Kibert 2016). Apart from the huge investment on time and money in a conventional construction project, meeting green goals needs additional effort in green construction project. Prominently, in feasibility phase of a green construction the viability of the project and particularly attainability of green goals are analysed (Jingxiao et al. 2019). Further, as shown in Figure 2 even in design phase of a green construction, attainability of green goals through the available budget and design team should be analysed. Therefore, the goals in green construction should be compared with available project details and past details of such projects. Nevertheless, limited knowledge in green construction is one of the greater barriers in adaptation and implementation of green concept in construction industry (Abubakar et al. 2019). As such, due to the limited knowledge on green construction among project participants at initial stages, the relevant communication can be deteriorated. Therefore, optimising the use of the available knowledge is important in effective communication in these stages in green construction (Kibert 2016). In the application of AI, knowledge representation and reasoning rationally understand the available knowledge, facts, and beliefs from the real world, and then make use of them to draw valid conclusions and facilitate logic inference in a transparent and efficient manner (Pan and Zhang, 2021). In the process of green certification, the communicating the data from construction site is highly considered as the construction process has the immense negative impact on the environment (Robichaud and Anantatmula, 2011). Computer vision, cloud virtual and augmented reality and Artificial Intelligence of Things allow to capture the real time and hidden data of the construction site. Extraction, storing, analysing and interpreting the data from the real world, stakeholders and construction site is needed in effective communication in every stage in green construction (Rawai et al. 2013). Further to that, the application of AI does such data extraction, storing, analysis and interpretation (Pan and Zhang 2021; Perera et al. 2020). Accordingly, this conceptual framework depicts a bridge of AI application in effective communication in green construction as per the literature findings considering the global context. It is clear that the application of AI will facilitate an effective communication in green construction.

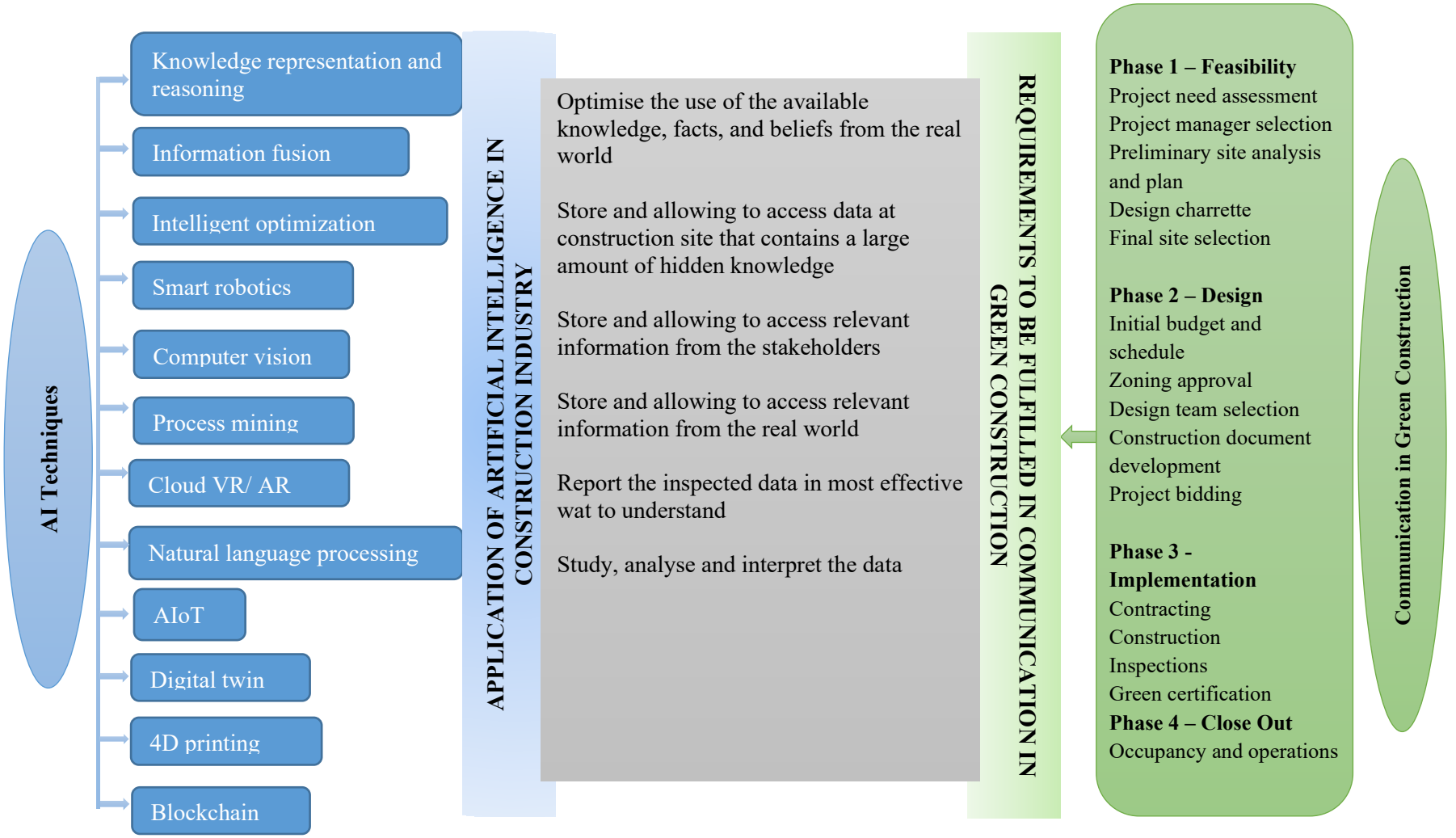

Figure 2. Conceptual Framework

Conclusion

The concept of green has penetrated into the construction industry mainly as the term of green building, to overcome the effects of its immense contribution in total energy consumption and greenhouse gas emission. There are different stakeholders involved in a building project through typical stages feasibility, design, implementation and close out. Therefore, there is a great need of communications which is systematic, understood by all stakeholders and intelligently applied. Nevertheless, the greater need of having an effective communication in green construction have been overlooked. The complexity of construction processes within the green construction projects necessitates the exchange of increasing amounts of data and information.

Notwithstanding the obvious advent around Industry 4.0 and its benefits, there is still a dearth in research for the potential application of its technologies. Nevertheless, the application of AI provides the ability to communicate and exchange data and information easily, efficiently, effectively and accurately independent of time and place, thereby providing major benefits for the collaboration in green construction. This application of AI will facilitate an effective communication in the green construction which will eventually ensure the delivery of applicable and reliable information to enhance collaboration within the construction supply chain and with project stakeholders. Yet, the research findings were completely based on a thorough analysis of literature which leads a way forward to continue the study to explore the application of AI for effective communication in green construction in the actual scenario.

Acknowledgements

The authors would like to acknowledge the financial assistance provided by the University of Moratuwa, Sri Lanka for the publication at the conference.

References

Abubakar, A., Behravesh, E., Rezapouraghdam, H., and Yildiz, S., Applying artificial intelligence technique to predict knowledge hiding behavior, *International Journal of Information Management,* vol. 49, pp. 45-57, doi:10.1016/j.ijinfomgt.2019.02.006. 2019.

Agyekum, K., Adinyira, E., Baiden, B., Ampratwum, G., and Duah, D., Barriers to the adoption of green certification of buildings: A thematic analysis of verbatim comments from built environment professionals, *Journal of Engineering, Design and Technology,* vol. 17, no. 5, pp. 1035-1055. doi:10.1108/JEDT-01-2019-0028, 2019.

Ahn, Y. H., and Pearce, A. R., Green construction: Contractor experiences, expectations, and perceptions, *Journal of Green Building*. doi:10.3992/jgb.2.3.106, 2017.

Ahn, Y., Shin, H., Jeon, M., and Jung, C., Construction process framework for a green building projects, *International Journal of Sustainable Building Technology and Urban Development*, pp. 349-364. doi:10.22712/susb.20170032, 2017.

Ali , H., and Nsairat, S., Developing a green building assessment tool for developing countries – Case, *Building and environment,* vol. 44, no. 5, pp. 1053-1064, 2009.

Chen, S., Jakeman, A., and Norton, J., Artificial intelligence techniques: an introduction to their use for modelling environmental systems, *Mathematics and computers in simulation,* vol. 78, no. 2, pp. 379-400, doi:10.1016/j.matcom.2008.01.028, 2008.

Darko, A., Chan, A., Yang, Y., Shan, M., He, B., and Gou, Z., Influences of barriers, drivers, and promotion strategies on green building technologies adoption in developing countries: The Ghanaian case, *Journal of Cleaner Production,* vol. 200, 2018.

Dwaikat, L., and Ali, K., Green buildings life cycle cost analysis and life cycle budget development: Practical applications, *Journal of Building Engineering,* vol. 18, pp. 303-311, doi:10.1016/j.jobe.2018.03.015, 2018.

Elforgani, M., Alnawawi, A., and Rahamat, I., The association between client qualities and design team attributes of green building projects, *ARPN Journal of Engineering and Applied Sciences,* vol. 9, no. 2, pp. 160-172. Retrieved from https://www.researchgate.net/profile/Mohamed-Elforgani/publication/286199375_The_association_between_clients%27_qualities_and_design_team_attributes_of_building_projects/links/5c099c9e4585157ac1adb665/The-association-between-clients-qualities-and-design-t, 2006

Ernest, J., Levine, R., and Lancaster, R., Green versus sutainability. vol. 2, no. 5, doi:10.1089/SUS.2009.9838, 2009.

Green, K. W., Impact of JIT, TQM and green supply chain practices on environmental sustainability, *Journal of manufacturing technology management*. doi:10.1108/jmtm-01-2018-0015, 2018.

Gunkel, D., Communication and artificial intelligence: Opportunities and challenges for the 21st century, *Communication +1,* vol. 1, no. 1, pp. 1-25, Retrieved from https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1007andcontext=cpo, 2012.

Guzman, A., and Lewis, S., Artificial intelligence and communication: A Human–Machine Communication research agenda, *New Media and Society,* vol. 22, no. 1, pp. 70-86. doi:10.1177/1461444819858691, 2020.

Hammond, S., Savage, D., Gajendran, T., and Maund, K., Stakeholders embrace green construction as the right direction: But as individuals they make self-interested decisions, *CIB World Building Congress, 2019.*

Hasan, M., and Zhang, R., Critical barriers and challenges in implementation of green construction in China, *International Journal of Current Engineering and Technology,* vol. 6, no. 2, pp. 435-445, 2016.

Henry, R., Role of Artificial Intelligence in new media (technology based perspective), *CSI Communications,* vol. 42, no. 10, pp. 23-25, 2019.

Hoffman, A., and Rebecca, H., Overcoming the social and psychological barriers to green building, *Organization and Environment,* vol. 21, no. 4, pp. 390-419, 2008.

Hossain, A., and Nadeem, A., Towards digitizing the construction industry: State of the art of construction 4.0, *Structural Engineering and Construction Management*, 1-6. Retrieved from https://www.researchgate.net/profile/Md-Hossan-6/publication/334670417_TOWARDS_DIGITIZING_THE_CONSTRUCTION_INDUSTRY_STATE_OF_THE_ART_OF_CONSTRUCTION_40/links/5d3940d2299bf1995b48772e/TOWARDS-DIGITIZING-THE-CONSTRUCTION-INDUSTRY-STATE-OF-THE-ART-OF-CONSTRU, 2019.

Hossain, M. U., and Ng, S. T., Influence of waste materials on buildings' life cycle environmental impacts, *Resources, Conservation and Recycling,* vol. 149, pp. 10-23. Retrieved from https://doi.org/10.1016/j.resconrec.2018.11.010, 2019.

Hussin, J. M., Rahaman, I. A., and Memon, A. H., The way forward in sustainable construction: Issues and challenges, *International Journal of Advances in Applied Sciences (IJAAS),* vol.2, no.1, pp. 15-24,2013.

Hwang, B., Leong, L., and Huh, Y., Sustainable green construction management: Schedule performance and improvement, *Technological and Economic Development of Economy,* vol. 19, no. 1, pp. 43-57. doi:10.3846/20294913.2013.869669, 2013.

International Labour Office and Geneva European commission, *Skills and occupational needs in green building.* Geneva: International Labour Office; Skills and Employability Department. Retrieved from https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_166822.pdf, 2011.

Jakesch, M., French, M., Ma, X., Hancock, J., and Naaman, M., AI-mediated communication: How the perception that profile text was written by ai affects trustworthiness, *In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pp. 1-13, Glasgow. doi:10.1145/3290605.3300469, 2019

Jayalath, A., and Gunawardhana, T., Towards sustainable constructions: Trends in Sri Lankan construction industry - a review, *International Conference on Real Estate Management and Valuation 2017*, pp. 137-143. Retrieved from https://www.researchgate.net/publication/320907730, 2017.

Jingxiao, Z., Li, H., Olanipekunc, A. O., and Baid, L., A successful delivery process of green buildings: The project owners' view, motivation and commitment, *Renewable energy*, pp.1-8, doi:10.1016/j.renene.2019.02.002, 2019.

Kibert, C., *Sustainable construction: green building design and delivery* (4th ed.). Hoboken, New Jersy, Canada: John Wiley and Sons, 2016.

Kim, M., Chi, H., Wang, X., and Ding, L., Automation and robotics in construction and civil engineering, *Journal of Intelligent and Robotic Systems,* vol. 79, no. 3, pp. 347, doi:10.1007/s10846-015-0252-9, 2015.

Kong, L., and Ma, B., Intelligent manufacturing model of construction industry based on Internet of Things technology, *The International Journal of Advanced Manufacturing Technology,* vol. 107, no. 3, pp. 1025-1037, doi:10.1007/s00170-019-04369-8, 2020.

Korchagina, O., Ostrovskaya, A., Yudina, O., and Ilyasova, O., Green construction. Eco houses, *Architecture and Construction,* vol. 3, no. 18, pp. 42-45, Retrieved from http://moofrnk.com/assets/files/journals/components-of-scientific-and-technological-progress/18/Components-of-Scientific-3(18).pdf#page=42, 2013.

Li, Y., Chen, P., Chew, D., Teo, C., and Ding, R., Critical project management factors of AEC firms for delivering green building projects in Singapore, *Journal of construction engineering and management,* vol. 137, no. 12, pp.1153-1163, doi:10.1061/(ASCE)CO.1943-7862.0000370, 2011.

Mesthrige, J., and Kwong, H., Criteria and barriers for the application of green building features in Hong Kong, *Smart and Sustainable Built Environment*, 2018.

Oesterreich, T., and Teuteberg, F., Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry, *Computers in Industry,* vol. 83, doi:10.1016/j.compind.2016.09.006, 2016.

Ogunmakinde, O., Sher, W., and Maund, K., Exploring the relationships between construction phases and sustainable construction principles, *In Proceedings of world sustainable built environment conference*, pp. 2771-2778, Hong Kong: International Co-Owners, 2017.

Olanrewaju, A., Tan, S., and Kwan, L., Roles of communication on performance of the construction sector, *Procedia engineering*, pp. 763-770, doi:10.1016/j.proeng.2017.08.005, 2017.

Olsson, E., and Rexmyr, J., Customer's perception of Neuro-Linguistic Programming (NLP) techniques in sales communication, 2017.

Pan, Y., and Zhang, L., Roles of artificial intelligence in construction engineering and management: A critical review and future trends, *Automation in Construction,* vol. 122, 103517, 2021.

Perera, S., Nanayakkara, S., Rodrigo, M., Senaratne, S., and Weinand, R., Blockchain technology: Is it hype or real in the construction industry, *Journal of Industrial Information Integration,* vol. 17, doi:10.1016/j.jii.2020.100125, 2020.

Raouf, A., and Al-Ghamdi, S., Framework to evaluate quality performance of green building delivery: construction and operational stage, *International Journal of Construction Management*, pp. 1-15, doi:10.1080/15623599.2020.1858539, 2020.

Rawai, N., Fathi, M., Abedi, M., and Rambat, S., Cloud computing for green construction management, *Third International Conference on Intelligent System Design and Engineering Applications*, pp. 432-435. IEEE, 2013.

Robichaud, L., and Anantatmula, V., Greening project management practices for sustainable construction, *Journal of management in engineering,* vol. 27, no. 1, pp. 48-57. doi:10.1061/(ASCE)ME.1943-5479.0000030, 2011.

Sarkis, J., Meade, L., and Presley, A., Incorporating sustainability into contractor evaluation and team formation, *Journal of cleaner production,* vol. 31*,* pp*.* 40-53. doi:10.1016/j.jclepro.2012.02.029, 2012.

Schia, M., The introduction of AI in the construction industry and its impact on human behavior, Retrieved from http://hdl.handle.net/11250/2634040, 2019.

Snyder, H., Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, vol. 104, pp. 333-339. doi:10.1016/j.jbusres.2019.07.039, 2019

Trandafilovic, I., Mnaic, M., and Blagojevic, A. , History of green marketing:The concept and development, International Symposium on Natur*al Resource Management,* vol. 7, pp. 260-271. Belgrade: John Naisbitt University. Retrieved from https://www.researchgate.net/publication/317348644, 2017.

Tsai, W., Yang, C., Chang, J., and Lee, H., An activity-based costing decision model for life cycle assessment in green building projects, *European Journal of Operational Research,* vol. 238, no. 2, pp. 607-619. doi:10.1016/j.ejor.2014.03.024, 2014.

Valdes-Vasquez, R., Blizzard, J., and Smith, A., Design Charrette: An important tool for the development of sustainable construction projects, Retrieved from https://www.researchgate.net/profile/Rodolfo-Valdes-Vasquez/publication/280533472_Design_Charrette_An_Important_Tool_for_the_Development_of_Sustainable_Construction_Projects/links/55b7fb4b08ae9289a08d4456/Design-Charrette-An-Important-Tool-for-the-Develop, 2014.

Vanegas, J. A., DuBose, J. R., and Pearce, A. R., Sustainable technologies for the building construction industry, *Design for the Global Environment Atlanta*, 1995.

Verma, S., Mandal, S., Robinson, S., Bajaj, D., and Saxena, A., Investment appraisal and financial benefits of corporate green buildings: a developing economy case study, *Built Environment Project and Asset Management*, 2021.

Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., and Nerini, F., The role of artificial intelligence in achieving the Sustainable Development Goals, *Nature communications,* vol. 11, no. 1, pp. 1-10. doi:10.1038/s41467-019-14108-y, 2020.

Waidyasekara, K., and Fernando, W., Benefits of adopting green concept for construction of buildings in Sri Lanka, 2012.

Wiesenberg, M., Zerfass, A., and Moreno, A., Big data and automation in strategic communication, *International journal of strategic communication,* vol. 11, no. 2, pp. 95-114. doi:10.1080/1553118X.2017.1285770, 2017.

Wimala, M., Akmalah, E., and Sururi, M., Breaking through the barriers to green building movement in Indonesia: Insights from building occupants, *Energy Procedia,* vol. 100, pp. 469-474, 2016.

Xiang, X., Li, Q., Khan, S., and Khalaf, O., Urban water resource management for sustainable environment planning using artificial intelligence techniques, *Environmental Impact Assessment Review,* vol. 86, 106515. doi:10.1016/j.eiar.2020.106515, 2021.

Ying, J., Pheng, S., and He, X., Green practices in the Chinese building industry: drivers and impediments, *Journal of Technology Management in China,* vol. 7, no. 1, pp. 50-63. doi:10.1108/17468771211207349, 2012.

Zerfass, A., Hagelstein, J., and Tench, R., Artificial intelligence in communication management: a cross-national study on adoption and knowledge, impact, challenges and risks, *Journal of Communication Management,* vol. 24, no. 4, pp. 377-389. doi:10.1108/JCOM-10-2019-0137, 2020.

Zulch, B. (2014). Communication skills impact on sustainable and green project management, *In World SB 4th Barcelona conference*. Retrieved from http://wsb14barcelona.org/programme/pdf_poster/P-182.pdf, 2014.

Zuo , J., and Zhao, Z.Y., Green building research–current status and future agenda :A review, *Renewable and Sustainable Energy Reviews,* vol. 30, pp. 271-281, 2014.

Biographies

K.I.Ridmika is a research scholar of Department of Building Economics, University of Moratuwa, Sri Lanka. She has obtained here Degree of Bachelor of Science in Quantity Surveying from University of Moratuwa with First Class Honours. Currently, she is reading her Master of Science (Major component by Research) Degree in the same university. As an early career researcher, Ridmika has published journal and conference papers. Further to that, she earned Diploma in Commercial Arbitration at Institute for the Development of Commercial Law and Practice in Sri Lanka. Her research interests are Dispute Management, Contract Administration, Sustainability, Green Concept, Building Information Modeling and Emerging Technologies.

Dr. Menaha Thayaparan is a Senior Lecturer at the Department of Building Economics, Faculty of Architecture, University of Moratuwa, Sri Lanka. She is a Fellow of Higher Education Academy (FHEA, UK). She has obtained her PhD in construction and property management at the School of the Built Environment, University of Salford, UK. Before joining the Department, Menaha was a Course Director of BSc in Commercial Management (Quantity Surveying) and a Senior Lecturer in Quantity Surveying at London South Bank University (LSBU), UK. She is a principal / co-investigator of a number of local and international collaborative research projects that are related to sustainability and disaster resilience. She has over fifteen years of teaching and research experience, and has published book chapter, journal articles, international conference papers, and research reports. Her research interests include disaster resilience, marginalized communities, higher education, built environment, green construction, circular economy and women in construction.