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ARTIFICIAL INTELLIGENCE IN PROPERTY MANAGEMENT AUTOMATION

– Technologies, Current Applications and Challenges

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Property Management Software (PMS) is a set of technological tools that can be used to address and anticipate many of the property-related challenges varying from property's predictive maintenance, energy-efficient solutions and improved residence satisfaction. Most of the modern Property Management Technology (PropTech) companies are building intelligence software to overcome possible challenges on property management sector through advanced technologies like Artificial Intelligence (AI) and Machine Learning (ML). While these technologies are used to automate various aspects of property management, it is also necessary to address if these technological advancements can create real impact and are not just a hype. This thesis introduces these technologies in the context of property management, examines how they can provide analytical, predictive and automation values, and postulates associated challenges.

To provide a complete overview on the best use cases of AI in property management automation, this thesis begins with the detailed research on application areas of AI on PMS – mainly chatbot integration, automation practices and data analytics. Afterwards, the advantages of having AI-driven technologies and challenges of collaborative integration are discussed.
The findings are pertinent to the AI technologies in the form of opportunities, use cases and challenges on property management automation. The thesis also analyses the potential utilization of data using AI-driven algorithms to predict outcomes, find the correct recommendations, and improve efficiency as well as productivity of every property management business.

KEYWORDS:

Property Management Automation, Artificial Intelligence, Machine Learning, Analytics, IoT, Software-as-a-Service.

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LIST OF ABBREVIATIONS (OR) SYMBOLS

AI	Artificial Intelligence
AR	Augmented Reality
AWS	Amazon Web Services
DL	Deep Learning
HVAC	Heating, Ventilation and Air Conditioning
IBM	International Business Machine
IoT	Internet of Things
KPIs	Key Performance Indicators
ML	Machine Learning
MVP	Minimum Viable Product
NLP	Natural Language Processing
PMS	Property Management Software
PropTech	Property Management Technology.
REST API	Representational State Transfer Application Programming Interface
SaaS	Software-as-a-Service
VR	Virtual Reality
WFM	Work Force Management

1 INTRODUCTION

Property management software technology is a set of online platforms and software tools used by different personnel in the property management business including owners, managers, investors, vendors, as well as the users like tenants and renters to collect, share and distribute the data related to property management. Core technologies that can create value for disruptive innovations on PMS include artificial intelligence, SaaS, big data, virtual and augmented realities (VR and AR), machine learning and robotics. Although the comprehensive PMS can be vast and covers many domains of discussions, this thesis focuses on the automation, streamlined communication through the AI-centered chatbots, and analytical values over the huge amount of generated data.

Based on findings from the 2019 Real Estate Industry Report for Residential Property Managers conducted by John Burns Consulting and Appfolio - the United States-based property management software firm, the lack of automation is slowing the growth of 35.1% of property management businesses. Too much time is spent with a pen, paper, and spreadsheets instead of letting modern technology take the load off, employees. (Appfolio, John Burns Real Estate Consulting, 2019)

This thesis provides useful insights into how disruptive technologies can be applied to address and anticipate the current need and discuss the future possibilities of their integration towards property management software. A particular focus is on the lack of proper automation between the property operational units and residents and energy efficiency policies on properties that can be addressed through proper utilization of these modern technologies.

Appfolio and John Burns Real Estate Consulting surveyed more than 500 property management professionals to bring data-driven insights into the state of the industry, which results in 77.7% of property managers are considering the adoption of new technologies (Appfolio, John Burns Real Estate Consulting, 2019) to streamline the property management services, which includes leveraging data related to property and aggregating them to analyze and enhance business processes.

By embracing AI-powered analytics, every raw data turn into a valuable piece of information to predict outcomes, to find correct recommendations, and to improve efficiency and productivity of every property. AI-integrated chatbots increase the residence satisfaction index through the advance recommendation knowing the

residents' behaviors and requirements; also, automatically respond to residents' queries round the clock with the full application of learning algorithms. AI-enabled IoT systems can be useful to identify patterns and detect anomalies which ultimately improves operational efficiency and eases the maintenance cycle. These systems also help to make informed business decisions regarding the property's health with predictive maintenance alerts

Therefore, this thesis studies technologies like Artificial Intelligence, Machine Learning, and IoT devices with respect to the Property Management scenario and discusses the key applications that convert the traditional software to the fully integrated PMS with the focus on automation and innovation. In addition to this, the thesis defines basic research to postulate the current practices and potential future possibilities and associated challenges of using Machine Learning to automate the property management process.

1.1 Context

In the world of property management, a growing number of automation functionalities rely on data. An extensive set of data are being captured, visualized and analyzed using the advanced computer algorithms to find out meaningful results and crunch the vast array of property insights. From data-driven business models to work order automation and sophisticated prediction model, the use of AI can lead to solving complex business decisions about every aspect of property management. So far, many PMS companies have not been to utilize AI on automating managerial and administrative tasks due to the volume of user data and the technological advancements required to process the data. Implementing Artificial intelligence in PMS is an advanced computing practice for bringing a wide-ranging application to lift up the automation process, but full potential is yet to be evolved.

1.2 Research Methodology

This thesis begins with the overview of artificial intelligence, machine learning and IoTs referring to academic papers, textbooks and online journals. This research approach aims to find actionable opportunities to identify the current problem every PMS is facing due to the lack of automation and unstructured data collection.

Resimator is the modern and comprehensive property management solution based on Turku Finland, built with the innovation on behalf of every aspect of property management that significantly lowers the communication overhead between different services required for the smooth running of properties. (Resimator Oy, 2019)

To accomplish the goal, initially two of the suitable research tools – questionnaires and interviews were used. To find out the possible use cases and gain a better understanding on how property management software, Resimator should be employing Artificial intelligence and IoT device data, a series of interviews and questionnaires' were carried out on with eight of the development and the sales team of the property management company Resimator. The interviews and the questionnaires aimed to answer the following questions:

1. How can artificial intelligence provide value on property management software?
2. What are actionable opportunities for application of AI in property management?
3. Are there possibilities of integrating other automation software with the current property management software?
4. Which of the application areas the thesis should be focusing during the initial phase and how should it proceed?
5. What is the degree of privacy and confidentiality using the company's materials and the software as a reference while writing the thesis?

Every property management software has their degree of concern over privacy regarding their technology and business insights, so the findings and materials presented in this thesis mostly reflect on how AI and IoT device data integration make the actionable opportunities on the current phase of Resimator rather than detailed technical information and algorithms used in such technology. Also, diagrams, infographics and tables

presented throughout the thesis were created solely for research on behalf of Resimator. In some cases, to acknowledge the best use cases, other PMS company's white papers and infographics are used as an inspiration.

1.3 Structure of the thesis

This thesis consists of six chapters defining the property management automation in addition to modern technologies, use cases and the challenges. It starts with the introduction, which covers the background and aim of the research following suitable research questions and a brief description of the property management automation. The second chapter defines the technologies behind the automation, including Artificial Intelligence with relevant technological terms.

Additionally, the third chapter of the thesis explores the current applications and sectors of property management, where robust technologies such as ML and AI can make a difference along with the advantages. It also discusses some of the findings of the property management automation status in Finland.

Furthermore, the fourth chapter of the thesis helps to explore a few of the most relevant use case of AI over the property management software. Following the use cases, the fifth chapter discusses the associated challenges of integrating AI over PMS. Finally, the last chapter ends up with the concluding remarks drawn from the findings.

2 OVERVIEW OF TECHNOLOGIES

This chapter defines the modern technologies related to property management automation, starting with artificial intelligence, machine learning and various associated terms. AI is the most common term heard and seen when it comes to the automation, whereas full application falls under its umbrella, including deep learning, machine learning, valuation, analytics and prediction regarding property management. With the help of technological advancements, experts and data scientists are developing software and computer systems that resolve complex challenges and minimize the human intervention to figure out actionable insights, broadly called Artificial Intelligence and Machine Learning.

AI is a vast topic that covers almost everything related to making computer intelligent and smarter. It works on the principle of combining a large sum of data, training and processing those data with the advanced algorithms to learn meaningful patterns and features that can create near-term prediction to of any business processes. Machine learning works under an automated system, where any software or computer device become trained from the set of algorithms and statistical modules relying on patterns and trends without the help of explicit instructions; whereas Deep Learning is a broader family of machine learning whose broader applications includes image and speech recognition, visual art processing, recommendations using modern learning techniques.

Figure 1 visualizes machine learning and deep learning as the subsets of Artificial intelligence and how they fit together:
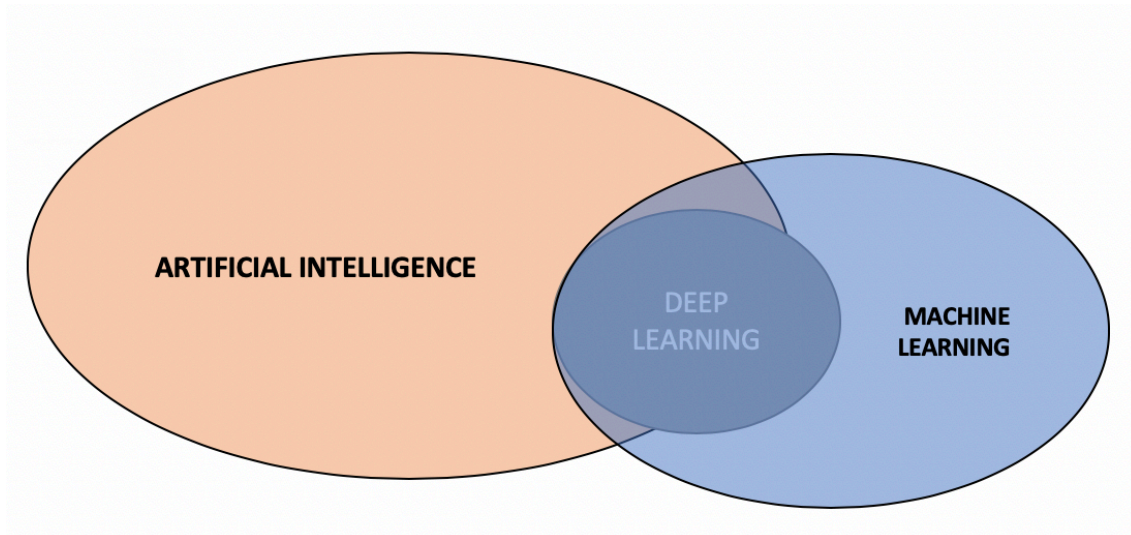
Figure 1. Illustration of the relationship between AI, ML and Deep Learning.

2.1 Artificial intelligence

The term Artificial intelligence was coined in 1956 and since then AI has become the frontier of automation in different industries. Advancement in computing capacitates and algorithms and a tremendous amount of data to train on gives more popularity to this technology. AI is the technological advancement in the machines/computers which learn from the past data and happenings, adjust to the new situation, and find a meaningful solution with less human intervention. It is also the method of training computer systems with large data sets to find out the meaningful outcomes and patterns using the advanced algorithms. This technology adds intelligence to any software to achieve incredible accuracy on the high-volume of computerized tasks for a variety of business process automation (SAS Insights, 2019).

2.2 Machine Learning

Machine learning is a subset of AI, which mainly studies with the algorithms and computational statistics to perform high-level intellectual tasks without human intervention. These algorithms are built based on collected data from various sources to study the patterns, predict the outcome, and make informed decisions for the future.

2.3 Neural Networks

Neural networks are one of the important components of machine learning applications. They are the set of algorithms, that are designed to recognize trends/patterns from various real-world data such as images, texts, images and sounds. They carry mathematical function to systematically collect and classify unstructured data based on the training from algorithm architecture to find the relationships between data and predict the outcomes. They carry wide applications in property management services, from forecasting and marketing research for fraud detection as well as financial risk assessment.

2.4 Deep Learning

Deep learning comes under the umbrella of machine learning where the computer is able to build complex concepts which can produce exceptional results, which in some case seems superior to the work of human experts. There are three main learning techniques supervised, semi-supervised or unsupervised learning.

Supervised learning: In this type of learning, algorithms examine the training samples of input data and observe the outcomes/results from this learning. Those outcomes are applied over the new inputs to learn and predict meaningful outcomes.

Semi-supervised learning: It is the type of learning where a typically large sum of unlabeled or unstructured data are trained with small amount of structured and labelled data to improve the learning accuracy on outcomes.

Unsupervised learning: It is a self-organized deep learning technique to uncover the hidden and unknown patterns in various data sets without the help of pre-existing data labels or patterns. Its main application is on the field of statistics to memorize and expand data features. (Russell,. and Norvig,. 2003).

2.5 Big data

The big data field of study systematically analyze and extract the valuable piece of information from a complex and large set of data with the help of modern, intuitive technologies. In today's world, data are collected continuously from vast information-

sensing devices like IoT, mobile/desktop software, sensors, microphones, where those big data help for predictive and behavioral analysis implementing AI technology. (Boyd. and Crawford, 2011).

2.6 Internet of Things

IoT devices are the set of connected devices that can either be computing devices or any digital objects with the embedded technology, that helps to collect the data from external surrounding like heat, temperature and thermostats, while those data can be collected and monitored through associate devices such as smartphones and computer. According to the report published by the CISCO, more than 500 billion devices are expected to be connected to the internet by 2030. (CISCO, 2019).

With the evolution of AI, IoT device data contribute to the collection and transfer of a large amount of data over networks for real-time analytics and automation (mainly home and building automation). Meanwhile, studying those data could potentially result in creating a sustainable and automated solution that provides users with a high quality of life.

2.7 Software as a Service

SaaS is one of the cloud-based software distribution models where third-party provides software/ application platform to make them available to any users, and all services are hosted through the cloud. SaaS provides remote access to the software functionalities through cloud-based networked services. Examples of SaaS in property management includes software offering services such as work-order automating, processing renter's information, accounting solutions and administrative functions.

2.8 Property management software

Property management software (PMS) technology is a set of online platform and software tools used by different personnel in the property management business, including owners, property managers, investors, vendors, as well as the users like tenants and renters to collect, share and distribute the data related to property management.

This software system facilitates the management process of properties, including day-to-day operations, maintenance, accounting, leasing, and more. Besides this, they help to organize, perform and schedule lengthy process and increase the efficiency simply updating and visualizing all the data and recording via a centralized computer system.

3 ARTIFICIAL INTELLIGENCE IN PROPERTY MANAGEMENT

This section of the thesis explores the current applications and sectors of property management where robust technologies like ML and AI can make a difference as well as depth look towards facility management and autonomous property systems. From buying and selling properties to their maintenance, energy efficiency, and many more, AI-based applications properly designed are beneficial for residence satisfaction and efficiencies of properties.

3.1 Property Management Technology (PropTech)

PropTech is commonly known as Property Technology, which is the use of technology to streamline the usual and traditional process of management and to innovate the tech-trends to reach the needs of the property industry. It is a new concept of technology that utilizes the modern technologies with cloud and digital transformation to minimize the cost for property-related problems, maximize efficiency and to personalize the way of property management. With the high-level understanding of the technologies used for the automation of the management process, it is found that various property managing functionalities are developed with specific purposes. Property management industry covers vast sectors and associated services which can be broken into various ways. For this research and based on the architecture of the complete PropTech, Table 1 covers the wide range of services along with the functionalities they cover to make the full use of AI in the property management process:

Table 1. Functionalities of Property Management Technologies.

Property Management Technologies	Functionalities
Property Management Software	Technological solutions for day-to-day operation; includes tenant/renter management, accounting transactions, and a portal to communicate between owners, managers and tenants.
Facility Management App	Quantifies the extensive property data (energy, water, power usages) and a platform to inspect properties focusing on efficiency and sustainability.
IoT for property management	IoT devices embedded on property premises for security, automation and energy management.
Data & Analytics	Collecting, engineering, and analyzing the data generated through PMS and IoT sensors.
Geospatial & Indoor Mapping	Property mapping and location services. 3D visualization platforms to interact with property structure plans.
Valuation	Intelligence valuation modeling to evaluate current and predict future value.
Property Operation: App/Web Portal for tenant/managers	Online portals and services for managing and operating the property.
Others	• Sales and leasing process automation. • Automated reports • Tools for automated booking process for laundry, parking, sauna, storages etc.

The wide range of software implementing machine learning and AI applications shows great ingenuity to reshape the way of property management and explore many sectors finding possibilities to solve the problems. However, most of the aspects of the property management process like booking system for the sauna, parking, storages, not necessarily need the use of AI. Simply property management software can automate the process of the booking system. Hence, the overall combination of all the above technologies listed above will undoubtedly create efficiencies and save cost and time to

unlock hidden opportunities which ultimately leads properties to attract more tenants/renters and new investment opportunities.

3.1.1 PropTech in Finland.

There are hundreds of property management technology firms operating around the Nordic and Baltic region, including and studying a few of them was a basis for this thesis and numbers are increasing. However, through this research, it became clear that employing Artificial Intelligence, and IoT devices data in their system is significantly rare and, in some cases, it is hard to notice.

Complying with various resources, personal interviews and online articles that are specific to property management, it is found that some of the property management software companies from Finland have just started implementing the modern technologies, i.e. AI and ML, for the work order automation within property management. PropTech Finland is an organization that focuses the Finish startup community on scaling and integrating innovative technologies into the property management business. Figure 2 visualizes the active companies and startups that are developing and innovating technological solutions for property management and automation sector.

Figure 2. Listing of the active startups working around Finland for property management automation using modern technological trends (PropTech Finland, 2019).

Here are some of the listings of the best findings of the trends and applications of intelligent technologies for the automation of the Finnish property market.

1. "As a small agile country, Finland is an early adopter of new technologies. The availability of open data and the stream of high-quality AI engineers and researchers produced by Finland's education system make this an ideal location for developing and piloting AI solutions. I believe that Finland will be one of the leading countries for utilizing and getting the most added value out of AI," says Reetu Kainulainen, CEO of ultimate.ai(A Finnish AI-based company designed to provide large enterprises' customer service agents with the AI tools they need to provide faster, smarter responses).

2. The largest companies on asset and property management service market are Realia Management, Newsec and Colliers International Finland. (Kti.fi., 2019).

3. There are some PMS for the optimized indoor climate, efficient communication and energy efficiency, which collects data from autonomous property system and provide them to the third-party application/platform via a REST API interface.

4. Nukka is a software service with works on Smart Building Management, enabling the transparency of all data on one platform and simplifying data to manage the property in a more sustainable, healthier and modern way. E.g. Varma, the largest pension insurance company from Finland, uses Nuuka's platform for energy management, space efficiency, garbage reporting and indoor climate mapping. (Nuukasolutions.com, 2019).

5. Houston Analytics, a leading European solution provider for analytics solutions and skills, helps to package, optimize and create a tailor solution and services for predictive analysis and technology-driven management. Besides, they provide:
   - Industrial & IoT: Leverage data and analytics to improve any property reliability, availability and efficiency.
   - Workforce Management: Adding predictive analysis to existing WFM solutions.
   - Adding intelligence to any business through analysis and forecast service and AI-powered solutions. (Houston Analytics, 2019)

3.2 Advantages of the AI-integrated PMS

In recent years, the rise of PropTech has transformed the way of managing and operating property units. With the deployment of modern and robust technological practices, every property manager benefits with the improved operational costs, situational awareness of the appliances and innovative ways to improve renters experience. This part of the thesis explores some of the most promising values of integrating AI over the PMS. Using modern technology for data collection and connectivity provides property managers with accurate information regarding operational & energy usage data. Moreover, they help to tackle maintenance and repair cost of assets by leveraging real-time statistics on operational and maintenance routine, which helps to boost the efficiency. From a

proactive approach of management to measuring lifecycle of appliances and automating the inspection and maintenance lifecycle to more significant property insights, AI proves to be the next frontier of Property Management and Automation. Figure 2 shows an extract of broader application and advantages of AI over every management and communication process in Property management.

Figure 3. Advantages of Artificial intelligence over the Property management process.

3.2.1 Automation

With the recent innovation and technological advancement, many routine tasks that used to take hours by human employees are automated, and machine or a system in many cases can perform faster and more accurately. For property management, in particular, a huge advancement in neural networks and algorithms made it possible to solve problems and make valuable decisions. This can be a streamlining process like leasing and renting automation, work-order automation or even accounting process with less human intervention. Most of the time-consuming, repetitive and prone to error tasks in property management includes the collection and analysis of data related to property and the resident's information. With the AI-based solution, that data/information can be stored and analyzed precisely. Some useful uses are discussed below:

- AI solutions that pull the data from the IoT devices or existing systems of PMS in real-time and uses algorithms to process them, helps to report automatically about property decisions regarding building safety and maintaining different functional systems.
- AI-integrated chatbots and software automatically respond over the text messages and emails regarding the maintenance and services of the property. Also helps with the scheduling the maintenance request and assigning to the concerned authorities.

3.2.2 Predictive maintenance and Situational alerts

Predictive maintenance is the technique to determine the condition of equipment or a system in order to predict when the failure is most likely to occur. AI algorithms can make a most relevant prediction with the help of past data and learning from patterns, regarding the functional lifetime of the property's system.

Predictive maintenance allows helps to identify potential weakness or probable response with the help of IoT data-driven data. AI algorithms have a huge ability to identify life cycle of inventories based on those data to predict how long certain system is most likely to operate.

With the advancement in technology, the data from IoT sensors are streamed over the software. AI-driven analytics and application of machine learning to evaluate those data in real-time helps to find out pattern and behavior of the system which ultimately leads to identify deterioration prior to malfunction. Over time predictive modules can produce most accurate predictions and situational alerts of any systems with the continuous learning from datasets.

3.2.3 Valuation and Prediction

Traditional ways of evaluating and predicting the property value seem inaccurate and face several difficulties. With the advancement in the technologies and introducing of the new predictive modules with machine learning algorithms, and their implication over the

data gathered from PMS; facilitates the study of the complete relationship between a property valuation and their affecting factors.

With the Key Performance Indicators of the PMS, all property performance regarding the status, usages and maintenance cycle powers the broad set of data. Those data powered by Natural Language Processors and high-performing data algorithms cross-validates the accurate valuation of the property and continuous extract of those data to predicts the valuation for the future.

3.2.4 Complete Data & Analytics

With the help of comprehensive PMS, all the data from internal and external systems can be visualized using the integrated Dashboard that displays the performance indexes of the property – into a single platform. Those data play a crucial role to uncover the hidden potentials and patterns on management and operational part along with the predictive insights to make future decisions based on those patterns. Today's real estate markets are loaded with lots of interconnected devices and systems. Such complex connectivity results in a downstream effect, i.e. if one of the systems fails or slows down that directly affects the whole connected system.

A complete PMS compromises the Key Performance Indicators (KPIs) on its integrated system. These are the set of measurement indicators that help to determine the operational, structural, financial and strategic status and achievement on real-time and visualize them on the integrated dashboard. Figure 4 visualizes the KPIs used in the Resimator Dashboard; they collect and visualize all property-related data over Resimator Dashboard for the complete overview of the operational and managerial part of the property management.
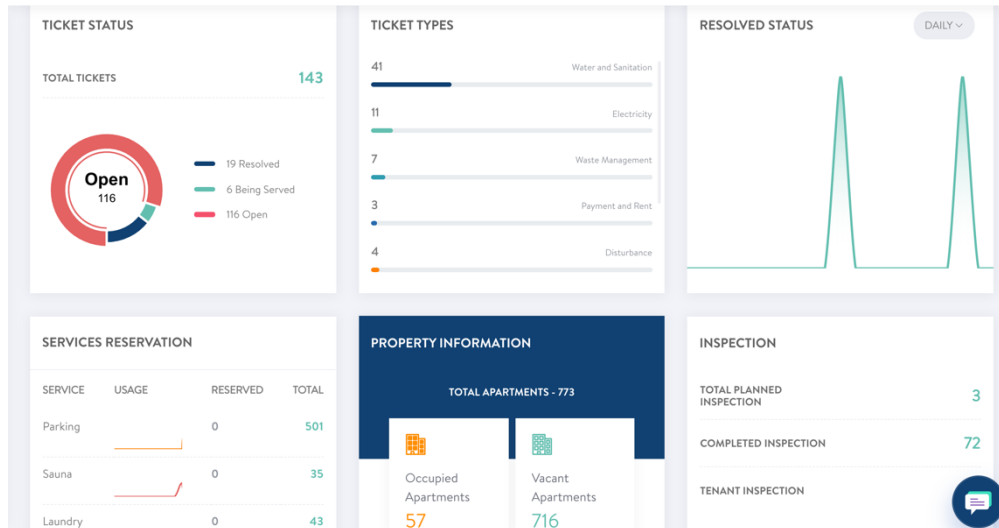
Figure 4. Various Performance Indicators on PMS(Resimator) dashboard showing the real-time statistics of property and maintenance data.´

To sum up, using just a property management software is not enough to stay ahead in your game, while integrating it with the innovative technologies opens up limitless possibilities in term of automation and efficiency. With the rich array of operational automation with modern software practices, helps every aspect of management to increase owner productivity, enhances renters experience and transform fragile and complex IT structures to an integrated digital platform.

4 APPLICATIONS

Most recently, AI in property management has been a surge in revolutionizing the way how operational and managerial tasks are automated ranging from monitoring the vital metrics of properties in real-time to predictive maintenance and providing statistics on property health. Today´s current and upcoming applications of AI certainly reduces human errors, operates customer service at any given time through chatbots and provides prior alerts to maintain every functional asset of properties. Whether it is reducing human efforts and maintaining the proper health of the property or superior analytical tools to monitor all performance systems continuously, AI-integration proves to be frontier on work-order & managerial automation. In addition to this, document analysis using NLP (Natural Language Processing) and round the clock customer service via intelligent chatbot are few of an essential application of AI. To explore a few of the most important uses of AI, this section of research explores the potential application with respect to PMS.

4.1 Implementing AI-integrated chatbot to PMS's live chat platform

According to Investopedia," A chatbot is a computer program that simulates the human conversation through voice commands or texts or both. A chatbot is a part of AI feature that can be embedded or integrated through any major messaging applications". (Investopedia, 2019)

With the advancement in technology, newly designed chatbots can understand written and spoken texts to some extent. Figure 5 illustrates the underlying working mechanism and values the conversational chatbot can provide to the property management software:

INTELLIGENT.
AI-powered software improves response over time.

ENGAGING.
Better renter's engagement through human-like interaction.

EFFECTIVE.
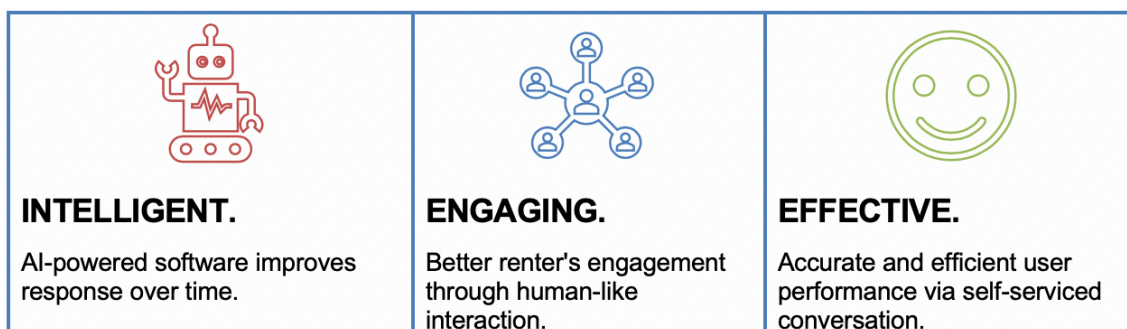Accurate and efficient user performance via self-serviced conversation.

Figure 5. Chatbots have a different level of valuable applications over Property Management Software. (Www2.deloitte.com, 2019a).

The current PMS of Resimator, features built-in service desk with a live chat client that supports video, audio and screen share options. Also, being a live-messaging platform, helps to connect easily with every web chat, app, social media messaging or voice interface. The scalable communication module is the most for every renters/resident to maintain proper contact with the housing managers or the responsible personnel to get informed about the property update, safety instructions/notices, maintenance request flows, to seek critical information on time through the live-messaging and responding system. Figure 6 displays the live messaging screen from the mobile and web interface and small touch of automation with automated reply to few of the queries processed.
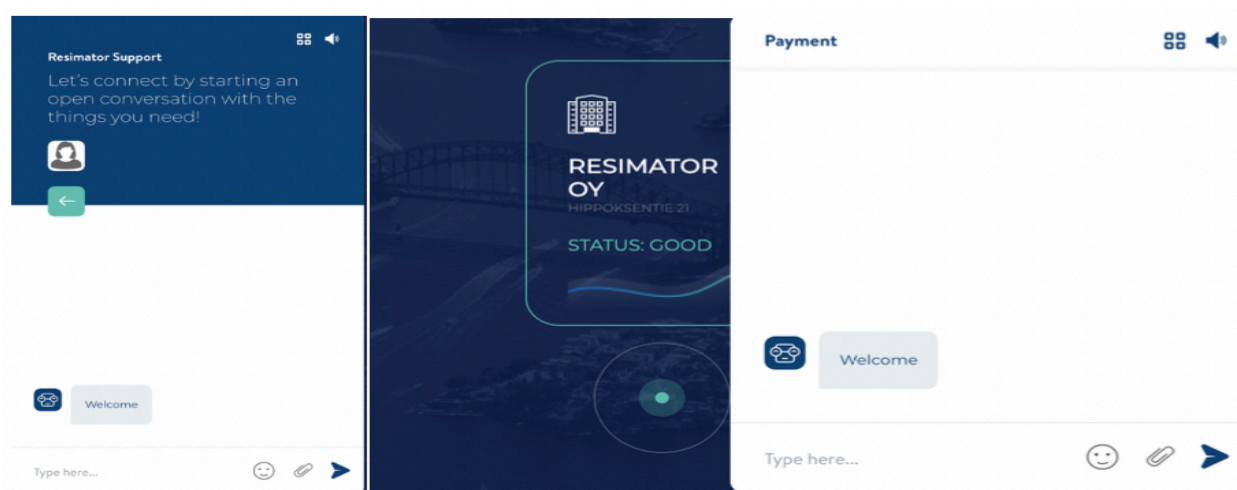

Figure 6. Mobile and Web chat interface of the PMS(Resimator) showing the automated reply to few queries.

The part of integration includes connecting third-party chatbot service providers to Resimator database, to provide dynamic information that can convert frequent customer/renter's queries to automated and valuable conversations. The integration mainly functions as real-time automated customer support with intelligently trained chatbots and engage the website/platform visitors understanding their intent and performs sentiment analysis through natural language processing algorithms.

Human-directed AI communicational chatbots should be trained with the huge sum of questions that are most likely to appear within property premises regarding maintenance, customer support, notices etc. Based on what renters/customers are looking for, the artificial conversation system can continuously increase the automation over customer

queries and PMS can bring the best renter experience. Figure 7 explains the values added through the integration of the chatbot service on PMS:
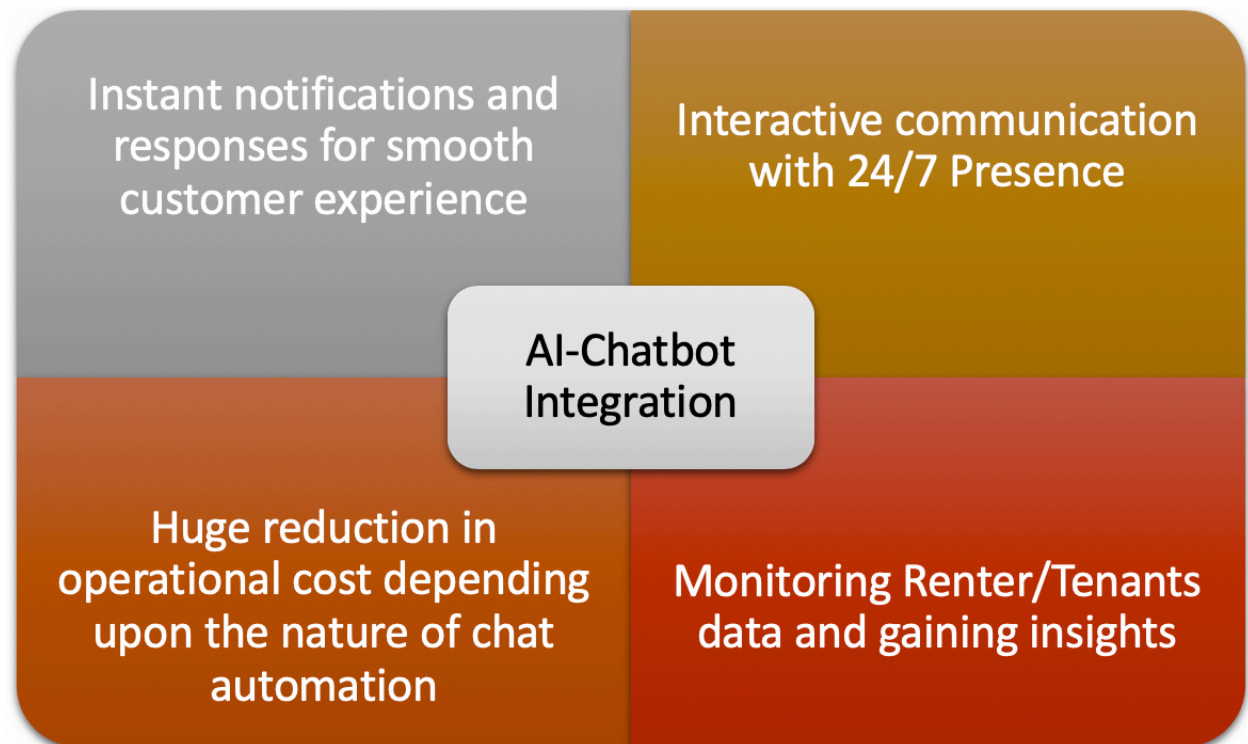

Figure 7. Values every property management software gets from AI-powered Chatbot integration.

When and how to integrate:

Before integrating the virtual assistant bot, there are lots of aspects to be considered, especially nature, needs, and their parameters. On top of property management, the following mentioned aspects should be considered before adopting this technology:

1. Researching on what nature of chatbot (FAQ chatbot, Virtual Assistant Chatbot or Virtual Agent) best suited for different nature of properties.
2. Chatbot being the customer-facing part of any application should always be visible and integrated wisely.
3. Connecting to the back-end database of Resimator (PMS) software to process and present a valuable and accurate conversation.
4. Integrating chatbot with some sort of automation into the current version of software to make it smarter and increase the efficiency of the system.

5. Creating a minimum viable product to get the review and customer experience from the early users or test users. It also helps to observe the actual user experience and behavior with the integration prior to the release of final version.

6. Research on recurring customer queries/expectations concerning property management, to figure out if they are ready to adopt.

Apart from selecting the right chatbot and their integration, the chatbot should be trained with a deep understanding of the property management industry and feed with the contents that guides to meaningful automated conversations.

Training the Chatbot software

Integrating chatbot is the starting point while training it to make it functional requires a lot of time and investment. Firstly, an integrated chatbot is yet to train with the algorithms that are mainly built with the domain of property management services; means understanding the customer's queries and know how to respond. Secondly, instructing the initial chatbot system how to talk and respond with the PMS's data systems to process requests via live chat and understand the subject matter. And, finally, evaluating the performance of training data on a periodic interval to recognize whether the queries of customers enquiries are answered as trained or appropriately handled. Also, in case of, changed data systems and software practices should be followed by re-training and modifying the training modules and algorithms that match the changing environment.

The process of training the chatbot can be illustrated with the help of Figure 8.

Untrained chatbot at PMS(live-chat)

Initially trained chatbot

Evaluating the trained chatbot

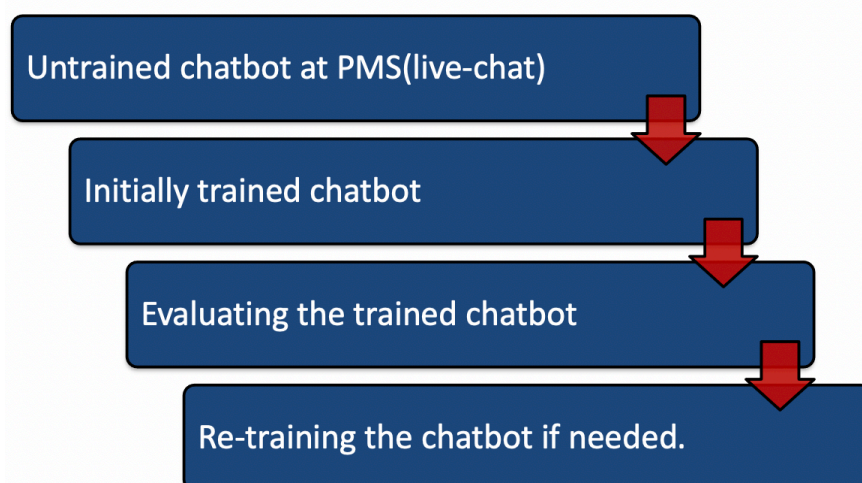Re-training the chatbot if needed.

Figure 8. Process of chatbot training.

The final process after training the chatbot with the set of algorithms is to integrate the artificial intelligence to turn chatbot from the entry-level machine to intelligence enough to identify and communicate as per the customers' needs and understand the patterns in property management business processes. Just like the human mind to need constant training, an artificially made conversational module, like chatbot needs continuous learning and experience. The success of such integration depends upon the experience the customers has with it and always get better learning from the customer queries and responses.

4.2 Integrating AI-powered Analytics on Property Management Software:

The science of data analytics includes processing and analyzing the raw data and information that are widely collected through various software; means using modern and robust technologies to follow the patterns and predict the outcomes. Resimator, being Property Management software with the advance Key Performance Indicators (KPIs), collects vast quantities of property-related data ranging from renters' details, maintenance and rental statistics, and revenues/expenses through various properties. With the integration of advanced predictive analytics tools, i.e. third-party predictive analytics software towards the current platform helps to figure out the meaningful relationship between causes and consequences, mining a vast set of data.

For this section of the thesis, integrating analytical module on current PMS covers huge applications of AI tools for data analysis, property valuation, risk assessment, and automating various business processes. Many property management software collects a significant amount of data on a daily basis in terms of properties and their residents. Also, predictive models are gaining popularity due to their abilities to streamline the assessment processes. However, the full potential of such model and their capabilities are not enough for every property management business owners and investors to invest and adopt new methods.

The current version of PMS consists of the integrated Dashboard that provides a set of KPIs to visualize, monitor, measure and maximize the performance of properties on real-time as shown in Figure 9. Analytical integration helps to provide more significant insights to the data collected from different sources within the single data warehouse.
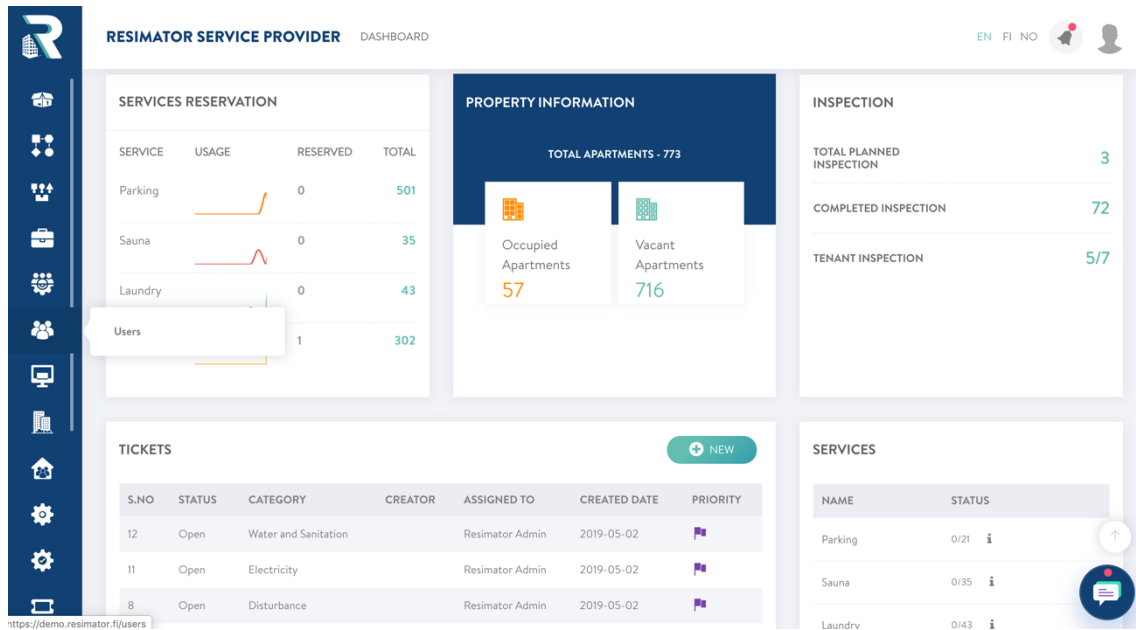
Figure 9. Dashboard of the property management software displaying KPIs and configuration modules.

When and how to integrate:

Data visualization and analytics carry the massive potential for PMS due to the constant increase in the amount of data from the software itself and other external devices. However, to achieve a fully integrated analytical user experience, both PMS functionality and predictive and forecasting functionality should be available to the platform. Figure 10 below illustrates the process every PMS should adopt to get significant results before adopting the correct predictive module for the business:

1. • Collection of the data through PMS KPIs

2. • Creating the predictive/analytical module to process various datas

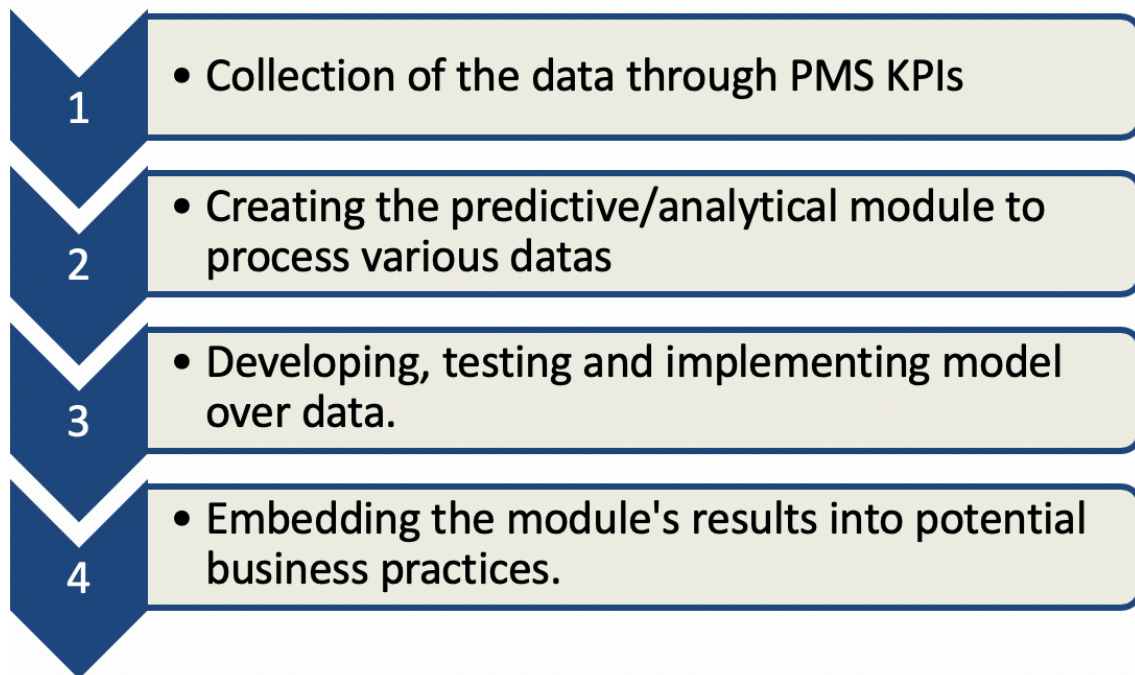3. • Developing, testing and implementing model over data.

4. • Embedding the module's results into potential business practices.

Figure 10. Stages of implementing the predictive analytics platform over property management software.

Implementing an AI-powered Analytics

With the implementation of AI-powered analytics, every valuable data that are collected over the PMS through different means can be monitored and analyzed. In terms of property management scenario, discovering insights of property data and predicting outcomes as well as valuable recommendations are some of the functionalities that AI-powered analytics platform brings. Advanced analytics tool combines dynamic data with the power of intelligence to discover insights in the larger picture and this section explains few of the functionalities the analytics bring towards any property management software.

Complete data exploration:

With the help of the business intelligence and advanced data-processing technology, every data collected from IoT devices, sensors and software can be visualized on the greater picture on PMS Dashboard. This helps to discover the patterns from the series of data, so every user and property managing personnel can relate to the visuals. In

Resimator PMS, KPIs handles all the property data and statistics and are displayed over the interactive Dashboard in real-time.

Interactive Reporting through Dashboard:

Visual data produces interactive reports which can be accessed by the end-users for data filtering and sorting. These reports are easily understandable by the non-technical users and can be accessed wherever and whenever necessary. The KPIs on the Dashboard is always running with live data. Simple drag and drop actions allow users to generate reports via KPIs and can be saved, shared and exported whenever necessary to a wide range of formats.

Augmented analytics

Augmented analytics helps to find out the relevant information from widely collected unstructured and raw data. Using trend and pattern recognition tools through Analytics integration helps to figure out meaningful discovery and explanations to the complex property management questions.

Predictive Insights

With the intelligence added over the analytics platform, every management and operational units of property not only see what happened at the past but also will unlock the value hidden in their unstructured data. It enables all management teams to identify future problems on the property and uses a predictive model for asset performance and find recommendations over future business decisions.

It is clear that, without AI-powered analytics, a range of PMS would struggle to aggregate data and reach the full potential of collected data to identify the current and future management problems that are most likely to appear. By embracing analytics, every raw data turn into the valuable piece of information, while analyzing those data and patterns automates manual processes to improve efficiency and productivity of every property.

4.3 Implementing AI over IoT data

Every property management company are moving towards sensors deployment and automating work through the implementation of IoT devices, aiming to provide operational efficiency, improved energy management and cost-effective management. A good PMS should be able to utilize all the data of the properties and integrate them into different systems. The number of sensors deployed over the property area is most likely to grow significantly and data gathered are collected over cloud-based platforms, learning and developing several areas, e.g. utilizing presence sensor for lighting control, energy management and deliver enhanced renter comfort. IoT data integrated monitoring platform will help IoT devices to collect property data, and those data can be transferred and monitored in an integrated dashboard through mobile and desktop devices. In sharp contrast, an IoT enabled PMS and the fully integrated software solution will focus on identifying where such devices can potentially create value in their management process and streamline the operational efficiency through sensor-generated data and enhance renters/resident's satisfaction index. Moreover, implementation of the IoT devices not only helps property managers or owners but also streamlines all the operational and managerial solutions.

IoT sensors involved in property management are many, and big providers of such devices include AWS IoT, Azure IoT, Thing Worx, Ubidots, IBM and Bluemix. Depending upon the functionality, these devices carry control over light, temperatures and heating systems. In addition, AI-driven digital experiences, smart energy meters, air quality monitoring, and improving the safety and security are primary uses of IoT to manage property smartly. The table below visualizes what IoT can offer to property managing personnel's and their usage. Each of the sensors plays important role in bringing automation on the housing industry and innovating renters experience. The lists illustrated on Figure 11 are still not exhaustive, while new trends and research are going on overtime to accommodate new uses of IoT devices.

Beneficiaries	Usage	Compatible sensor types
• Residents • Owners • Vendors & • Investors	Property premises (Indoor/Outdoor)	• Smart trash bins • HVAC • Thermostats • Light • Advanced Smoke/Fire sensors • Motion sensors • Water/pipes monitoring and more...

Figure 11. Potential use cases and IoT sensors for Property Management Automation, their usages and beneficiaries.

IoT-devices functional cycle with PMS.

With the connectivity of various types of sensors on property premises can track features like motion, pressure, temperature, light etc. and then - with the integrated backend framework of Property Management Software (PMS), those data can be monitored on KPIs to communicate, analyze or act/react with other machines or people in a nonintrusive manner.

Sensor deployment turns any physical objects into a source of information through data collection, and PMS framework provides an interface to visualize those data. Figure 12 illustrates the ecosystem of connected devices which are embedded over the property premises to monitor every activity from property appliances functionalities, building health and energy uses. Those devices collect valuable data and send them over the property management software where data are turned out into valuable insights with the help of AI.
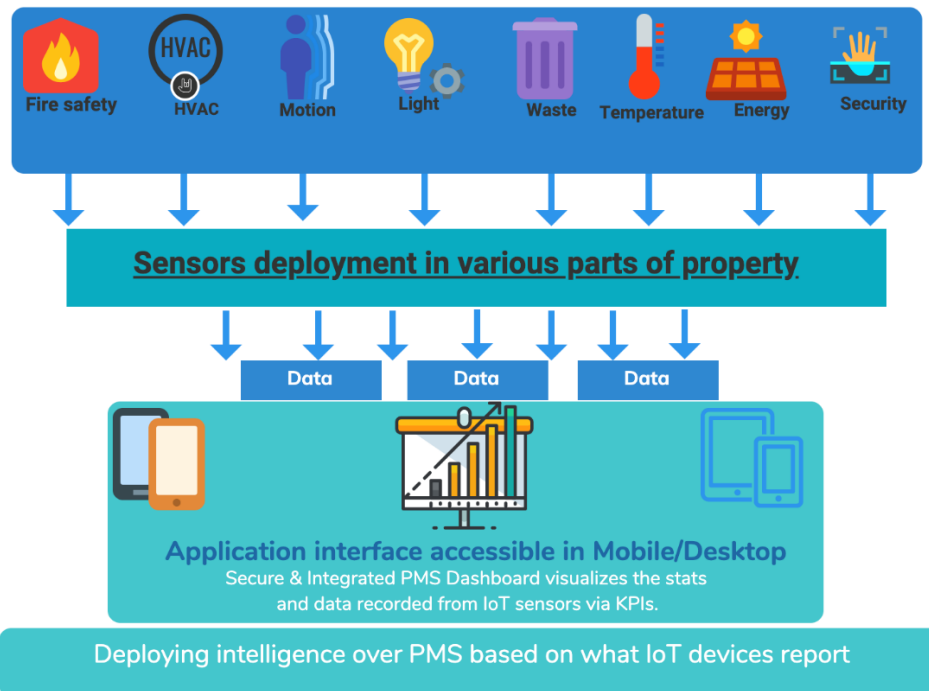
Figure 12. IoT device data collection and evaluation process through the integrated Property Management Software. (Made by using the online tool: venngage.com)

For the successful IoT implementation, there comes a series of data collecting and processing procedures. It starts with the collection of data through IoT systems embedded on the property to visualizing them through PMS and applying AI- integrated technologies to collect meaningful information and situational alerts.

Those massive and unstructured data are challenging to organize using traditional ways. And, this is where AI plays the role. With the advanced machine learning algorithms, every data is examined having patterns and values, without human operators.

Figure 13 below illustrates the process from collecting data from the sensors, their aggregation and adding intelligence through advanced technology. (www2.deloitte.com, 2019b).
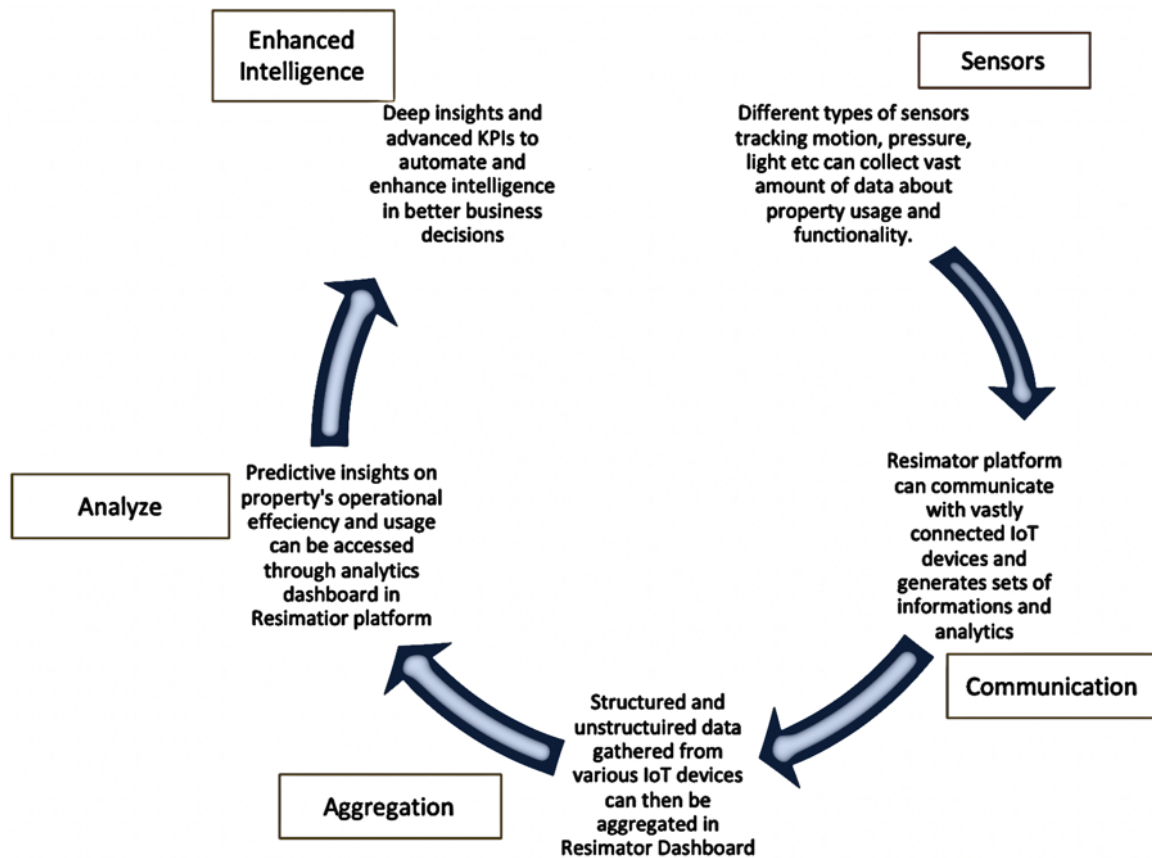
Figure 13. Functional architecture of collecting property-related data and integrating intelligence over them on Property management automation.

The relationship between IoT device data and AI is significant in forming a complete and advanced system where data meets intelligence. Together, these high-performance functionality IoT devices and advancement in technology, intelligent algorithms and analytics software are ushering in automating every aspect of property management. However, with the exceptional rise in IoT devices and continuously changing data generated creates some security and privacy uses and demand for the large enterprise of particular types of equipment and skilled workforce.

5 CHALLENGES

The combine disruption of implementing AI and IoT data to PMS has huge potential using data and analytics to raise productivity, reduce human effort, improved decision making and support the modern way of living by connecting different applications. However, numerous challenges arise at the same time being the diverse and complex set of connected devices and require hefty investment as well as new skills and expertise to integrate all the devices/resources and manage them to handle large amounts of data.

At the same time, before integrating any kinds of AI apps or platforms, every property managing software's and firms must understand and address what their needs are rather than experimenting their business and software with AI. To overcome the challenges, companies considering implementing AI capabilities should firstly find the answer to the following questions:

- Does AI-based augmentation make a difference in a business process or create chaos on an existing solution?
- Will AI integrated predictive models deliver better business insights towards your property and bring positive outcomes financially?

Below are some of the major challenges most of the company face while integrating AI-based solutions.

5.1 Integration and interoperability

To gain a better insight on every prospect of property management, IoT devices and AI-enabled software must bring together diverse data types depending upon the nature and necessity of the resources. The large scale of sensors with different functionalities like energy consumption regulators, communication bandwidths and security enhancements are built by different manufacturers that do not necessarily comply with a common standard and does not connect to the internet the way typical computer devices do. (Faggella, D., 2019).

With the adoption of any new technologies, every company must deal with the changing management issues for integrating and implementing IoT devices and keep the balance between new technologies and leveraging existing ones. Other emerging challenges in the AI industry includes:

- Industry-based expertise for constant improvement in AI systems.
- Natural User Interface (NUI) to interact and process information via human behavior, environment, intent and emotions.

5.2 Leveraging the data

One of the biggest strengths of implementing the core technologies to the property management is an exponentially large amount of data are readily available which contains a valuable set of information regarding the residents and the management of the property. However, collecting raw data from software and sensors, which are mostly incomplete and inaccurate requires essential data management utilities that are part of the property management process.

The main challenge is that every organization must have a constant source to keep the data up and running. Since tremendous data scatter in the form of text, image, audio and video, there comes the challenge to build accurate models and algorithms to provide accurate results. In addition to this, handling, computing, scaling and securing those data are crucial components necessary for every organization to deploy data-driven technologies towards their solution. On the other hand, small embedded devices are always in verse of collecting sensitive data knowingly and unknowingly which creates a challenge in moving and integrating those data to cloud-based software database because of their volume, sensitivity and latency requirements.

5.3 Massive Computing Capacity and Time

Massive computing challenge resembles with the ability to store, deploy and securely analyze data at massive scale. Continuous studying of the patterns, training large scale data with advanced algorithms and applying human intelligence to convert them into practical results requires modern and comprehensive computing technologies and a tremendous amount of time. AI-algorithms need to be fed and trained with a massive amount of data over a long period. Additionally, for successful results, expensive computer software/hardware and advance knowledge in AI-working mechanism and mathematics is also a challenge for every company who intend to implement these technologies.

5.4 Security and Privacy

Despite having a massive impact on the data collection and analysis process, these technologies pose risks of data security and privacy at the same time. Especially while dealing with the tenant and property's confidential information, require several utilities to process the data securely. Since IoT allows for direct control of physical devices which pose risks of malware like viruses, potentially resulting in the security threats in large scale.

Due to the vast interconnectivity of embedded devices and their data capturing process, there always arise concerns regarding data privacy and cybersecurity issues. The more the IoT-enabled devices and more large networks of such devices, the more systematic and sensitive data are collected from property premises. This will possibly widen the attack zones for the hackers to cause the data breach and stealing of the sensitive information; which ultimately leads to financial and reputational damage to the residents and property governing bodies.

6 CONCLUSION

While automating various aspects of property management and implementing robust technologies over PMS has achieved huge advancement in recent years, there is still a vast potential to uncover. Undoubtedly, with the advance applications of Artificial Intelligence in Property Management Software, every routine task of management becomes automated, and the use of data can help to find out meaningful insights to make better business decisions, increase efficiencies, and improve residence satisfaction. This thesis started with the introduction to some of the modern technologies and a comprehensive review of PropTech, followed by a few key applications to make full use of data on automation. Additionally, it also discussed the associated challenges of implementing AI and some of the privacy issues that might occur due to the data collection from the properties and the residents. Finally, three of the most disseminating applications – human-directed chat bot, analytics and IoT device data-driven intelligence – were shortly reviewed.

Data collection has become one of an integral part of the property management, and IoT devices and software are collecting a vast amount of data ranging from energy and resource consumption to overall property operating systems and resident's information. With the implementation of AI on data-based analytical software, every data generated is turned out into the meaningful piece of information that can offer every property managing personnel with the informed business decisions regarding the property's health with predictive maintenance alerts. Meanwhile, implementing AI on PMS also increases the residence satisfaction index through the advance recommendation knowing their behaviors and requirements. Some of the applications discussed over this thesis are AI-integrated chatbots which automatically respond resident's queries with the full application of AI. Not only do they provide round a clock service, but they also collect a significant amount of essential data which can be utilized to understand customer behavior and provide a customized solution. Secondly, combining the IoT devices' data with AI/ML technologies can create adaptive learning and analytical system that makes the management process intelligent and cognitive. Additionally, AI-enabled IoT systems can be useful to identify patterns and detect anomalies which ultimately improves

operational efficiency and eases maintenance cycle. Lastly, integrating AI-powered analytical functionalities over the data collected via software and hardware used during property management process helps to explore the relationships and patterns from the past data to predict future occurrences, which ultimately helps with complex business decisions.

Many property management software companies can benefit from third-party advanced AI solutions providers that can automate various lengthy and tedious tasks to increase operational efficiencies of any property. Such integration to PMS can automatically engage and improve for better conversion to provide a stellar experience for customer/renter service. This thesis uncovers the following main findings:

- Most of the early adopters' PMS companies and startups investing in AI are having positive results, but challenges still exist in collecting data and building the machine learning algorithms.
- On the one hand, there is a shortage of technical human resources and skills, but on the other there lacks the strategic approach that automates the machine to its best.

Hence, using robust algorithms for rent pricing, accounting process automation, lease performance data helps to recommend the perfect and market-based pricing and valuation, while reducing the burden of manual data extraction, calculation and analysis. From every finding from this thesis, it is clear that AI and automation technologies are unlocking the hidden potential of property management. In addition to this, cognitive technologies hold enticing promise, some of which is being fulfilled today. However, AI technologies may deliver their best returns when companies balance excitement over their potential with the ability to execute.

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