HIGH AVAILABILITY WITH DEMOCRATIZED INTELLIGENCE

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ABSTRACT

This article showcases the AI capabilities of Capgemini Engineering Services. It aims to add unique differentiation of "high availability" feature in Distributed AI context.

Engineering Analytics CoE

Digital Engineering and Manufacturing Services

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1. EXECUTIVE SUMMARY

Industries are always in continuous demand of highly efficient and cost-effective solutions without compromising human and machine safety. Artificial Intelligence (AI) enabled by emerging digital technologies has a vital role in addressing these business needs. Most AI solutions today are 'centralized' in nature – asking for massively large datasets, expensive computing resources and as well requiring periodic tuning and optimization of complex and sophisticated AI models.

Centralized models, in the long run, could also gradually lead to the monopolization of the AI marketspace, which eventually could confine the participation of other organizations in AI innovation.

Nonetheless, thanks to the advent of technologies such as mobile and edge computing or on-device analytics, we can now have huge potential to enable faster decision-making by a direct machine to machine (M2M) communication in a much adept fashion without the need for a centralized hub. The decentralized AI, when exercised properly, could potentially enable democratization of the AI marketspace.

The current paper extends the notion of decentralized AI to *collaborative AI*. This work illustrates how a very *High Availability* can be achieved *With Democratized Intelligence*, concisely called *HAWDI* platform, in the context of a warehouse example which involves multiple robots that are situationally aware of their workspace and intelligently collaborate with each other for accomplishing specific tasks with their resource pooling.

The article further demonstrates how *HAWDI* platform addresses functionalities such as fault tolerance and smart scale-up, besides other features like machine-vision and machine-learning. The solutions are implemented on a low-cost hardware (Raspberry Pi) with an off-the-shelf OS.

This demonstration opens-up the possibilities of tapping $550bn [Gartner, April 2018] of forecasted global business value for smart and intelligent products (edge devices) in the upcoming 5 years.

2. STATE OF THE ART – AI IN IOT

Artificial intelligence (AI) in today's world encircles myriad of things, say from prediction algorithms to chat bots to autonomous devices. Such manifestations of AI once again underscore that human intelligence when complimented or amplified by artificial intelligence undoubtedly has a huge potential to address certain complex industrial challenges. Performing a narrow task, be it web search or facial recognition is often referred as 'weak AI' [2]. With growing demand for autonomous devices and vehicles, the need to transition from weak AI to 'strong' or 'generic AI' is ever increasing. This paper is an attempt to move one step closer to that goal.

2.1 KEY ELEMENTS OF AI SOLUTION

IOT solutions built today inherently assume a centralization model at its core. It is essentially made up of four elements: Data/Knowledge, Model, Learning, and Regularization / Optimization (the emphasis being on having a robust and scalable training model). Thus, the lifecycle of an AI system assumes that there is a model and, sufficient dataset/knowledge base which is used to train the model, that also constantly requires regularization and optimization to deliver more accurate outcomes.

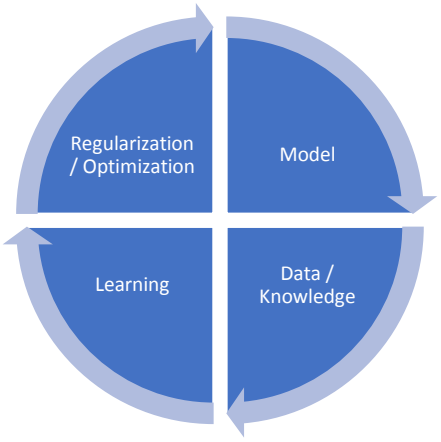

Figure 1: Four key elements of AI solution

2.2 NEED FOR AI DEMOCRATIZATION IN IOT

The machine intelligence systems of tech giants such as Amazon, Facebook, and Google are becoming integral part of our daily life. The data assets acquired by those companies over the period offered them an economic advantage by facilitating early capitalization.

IT LEADERS MUST FOLLOW THE TREND OF AI DEMOCRATIZATION TO DRIVE THEIR TEAMS TO CREATE AI SOLUTIONS.

"Predicts 2019", Gartner, Nov 2018

The threat here is that this could gradually lead to the monopolization of the AI marketspace and could cause unfair pricing and lack of transparency. This predominance eventually could also confine the contribution of the other organizations to AI innovation. Thankfully, the inception of decentralized AI and edge computing with a wide choice of Industrial IOT framework tuned for

a given domain is turning out to be the solution [3-5].

2.3 CENTRALIZED AI VS DECENTRALIZED AI

Centralized architecture relies on single central decision-making engine (located either on private or public cloud) where intelligence is built using massively large datasets acquired from disparate sources, be it sensors or robots at different locations. The data is then analyzed, decision is determined and communicated back to the source locations for the necessary action.

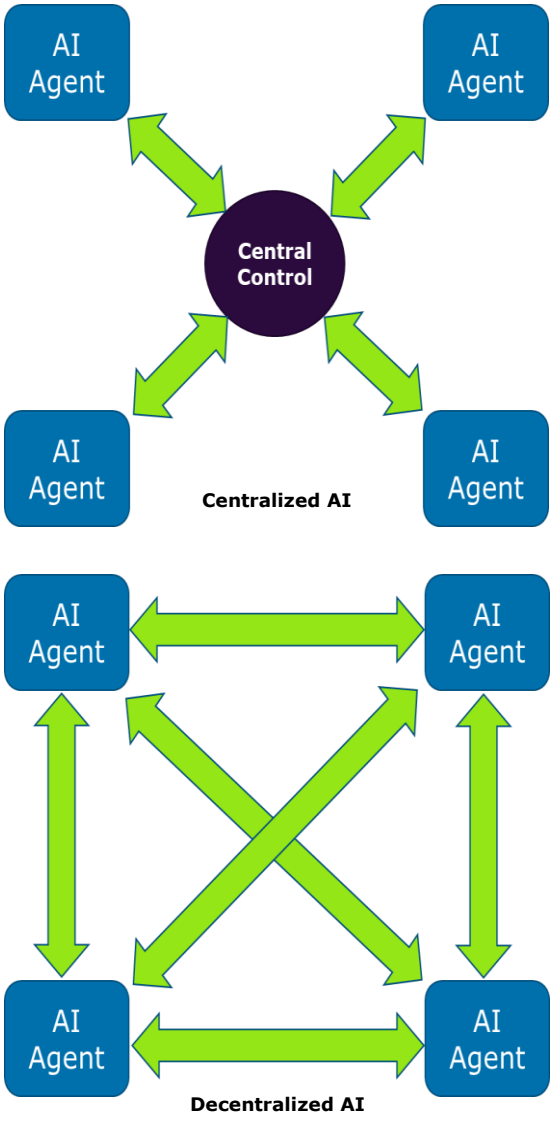

Figure 2: Centralized AI vs Decentralized AI

This traditional approach suffers from certain limitations:

- Data generated at source is more often raw, unstructured and sometimes duplicated, thus incurring considerable bandwidth costs due to redundant analysis of non-ready data
- Prediction models developed using sophisticated machine-learning models require periodic tuning and optimization thus demanding very expensive computing resources due to massive data involved
- Data located on cloud is prone to security threats
- High latency and network disruptions can cause service outages

Decentralized AI or Distributed AI, on the contrary, solely relies on the computing power of edge devices. The edge devices have evolved over the years, from MHz to GHz, from single-core to multi-core. This enables technologies such as IPC, Containerization to deploy software services, distributed database architectures, local cache mechanisms to be used due to increased computing power. Today, technologies have become lighter and high computing power is available at low cost, thus making edge devices suitable to act

as AI agents in decentralized environment.

AI-based edge computing deals with complex AI algorithms running on Edge/IOT devices like smart sensors, security cameras, drones or autonomous vehicles. Thus, the operations of data processing, knowledge extraction and decision-making are fully localized. By conducting such on-device analytics, the need for dedicated centralized data processing center and centralized decision-making engine can be eliminated. This offers several advantages:

- Instantaneous decision-making due to reduced data transfer distance and data size
- Smart edge devices enable efficient collaboration via device to device communication
- Edge devices can be software-defined thus bringing in a lot of flexibility in their usage
- Easily scalable at much lower cost as per the desired computing power on a specific edge device
- Low or almost nil dependency on network connectivity

Decentralized solutions can radically democratize the AI market in the long run through a single protocol and the development of interoperability standards, which will ultimately lead us to strong or generic AI, possibly using multidimensional, multilayer networks of such interconnected AI agents.

3. DEMOCRATIZED AI – THE PROPOSITION

IOT devices typically act as information nodes managed by a central processor. Centralized intelligence in industrial IOT is an established practice. However, it has inherent disadvantages in risk averse systems. The IOT devices do not collaborate with each other for collective decision-making.

Democratized Intelligence is the notion coming from the natural swarm systems, e.g. bees, ants, birds, etc. that collaboratively work together locally with no centralized control and collectively produce a global interesting behavior. These agents, insects or swarm individuals, are relatively unsophisticated with limited capabilities as individuals, but they interact together with certain behavioral patterns to cooperatively achieve tasks necessary for their survival [6].

Figure 3: Swarm of bees collectively exhibiting a distinct 3D pattern

Democratized Intelligence enables a group of Edge/IOT devices to communicate between each other in publisher-subscriber pattern, collaborate and collectively take intelligent decisions in real-time. It relies on truly distributed architecture generating non-conflicting intelligent actions with mutual consent. It also enables the devices to functionally reconfigure themselves based on the environmental changes.

The key ingredients of our Democratized AI proposition are:

(a) Sensing (e.g. Machine Vision) for knowledge gathering and environment perception

(b) Low cost, connected, smart edge devices or AI agents

(c) On-edge set of cognitive algorithms offering Collaborative / Edge intelligence

The unique differentiation of this proposition is its "high availability" feature achieved through 1:N level of redundancy. This means that if one of the agents in the *swarm* is not available for some reason, the neighboring agent automatically takes its role and shares the work optimally with the others. Furthermore, when the agent becomes available again the situation returns to normalcy as before. The scale-up can be

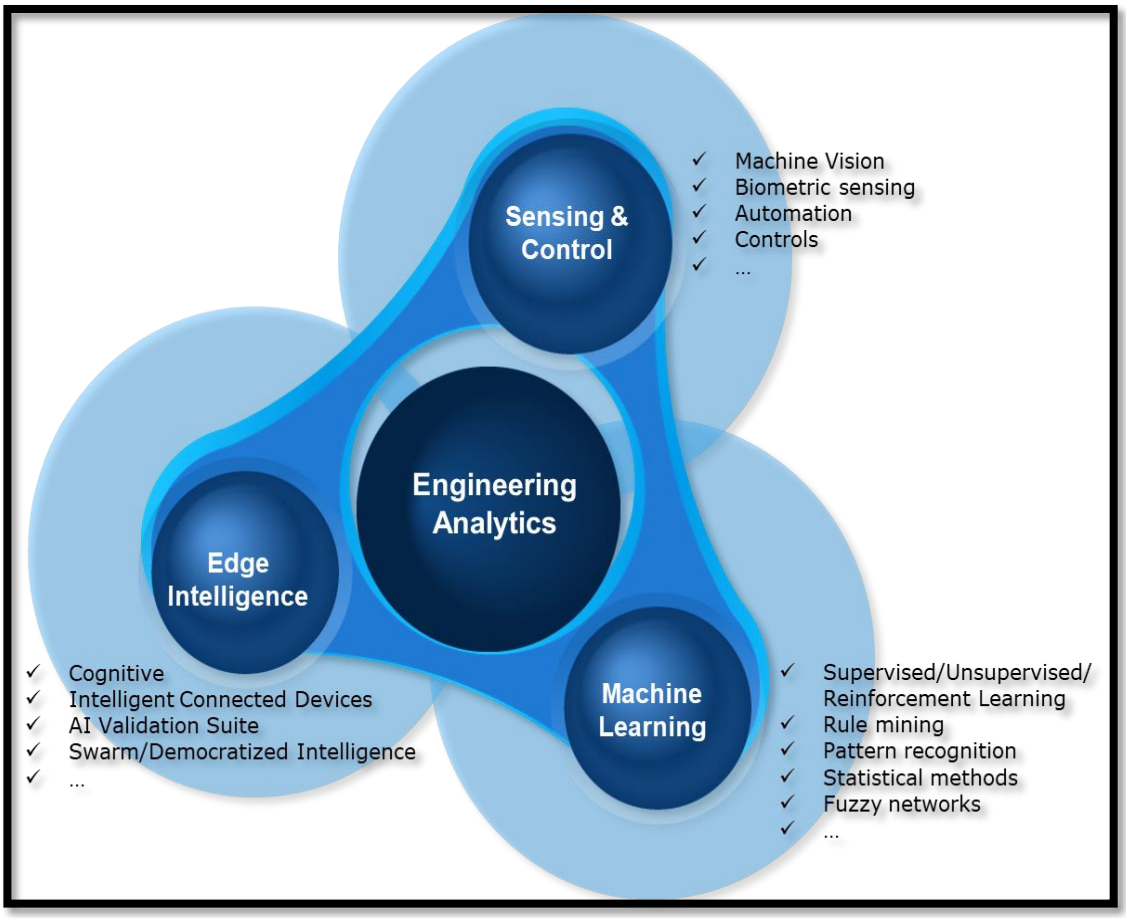

Figure 4: Enablers for Democratized Intelligence

achieved by introducing a new member to the group and the group redistributes the work load.

Devices are thus empowered with local decision-making ability through enhanced situational awareness in relationship with each other in the chain.

This is realized through a powerful platform – *High Availability With Democratized Intelligence* (*HAWDI*), applicable for several problems in multiple domains. Some important applications are briefed further in sections below.

4. HAWDI CASE STUDY

The case study consists of multiple robots that are tasked to patrol in the designated zones and transport objects on its way. This is the case of warehouse forklifting where goods are to be carried from the unloading zones to the specified stockers.

The robots are equipped with an optical camera for environment perception of the workplace and a Raspberry-Pi for conducting edge analytics. Image processing algorithms are accordingly optimized for on-device analytics. Edge machine vision thus provides necessary real-time learning aids for each robot.

The communication between robots takes place wirelessly via WiFi protocol. The robots continuously exchange their health and location status with each other. The intelligence is built on every robot using ML and cognitive algorithms that provide capabilities for collective, optimal decisions and collaborative operations without any need of a centralized processor.

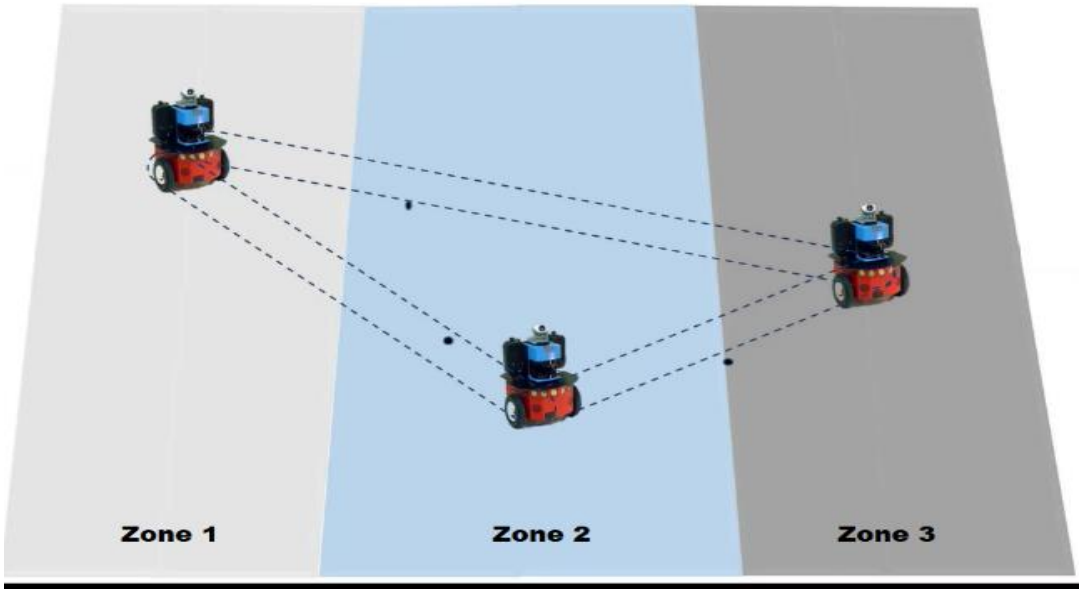

Figure 5: Three robots collaborating with each other from their designated zones

4.1 COLLABORATION SCENARIOS

In the standard operating scenario, whenever an object is detected in a zone, the respective robot will approach the object, pick and drop at either of the ends of its designated zone. However, there may arise multiple scenarios where collaboration becomes the key:

(a) An object in Zone 2 is not in line of sight of Robot 2. Robot 1 or Robot 3 may detect that object and communicate it to Robot 2 for necessary action.

(b) An object that falls on the zone boundary may attract the attention of two robots. Robots mutually take a decision based on the proximity to the object.

(c) When a robot fails, say Robot 2, the other two robots communicate and auto-provision their work areas to accommodate the designated zone of Robot 2 and continue patrolling accordingly.

(d) When a failed robot resumes to work again, the three robots re-provision their work areas and return to the normal operation.

4.2 SYSTEM ARCHITECTURE

Democratized AI system architecture in this case study essentially consists of four modules viz., Machine Vision Processor, Situational Awareness Module, Collaborative Intelligence Module and Business Logic Module as illustrated in the block diagram in Fig. 6.

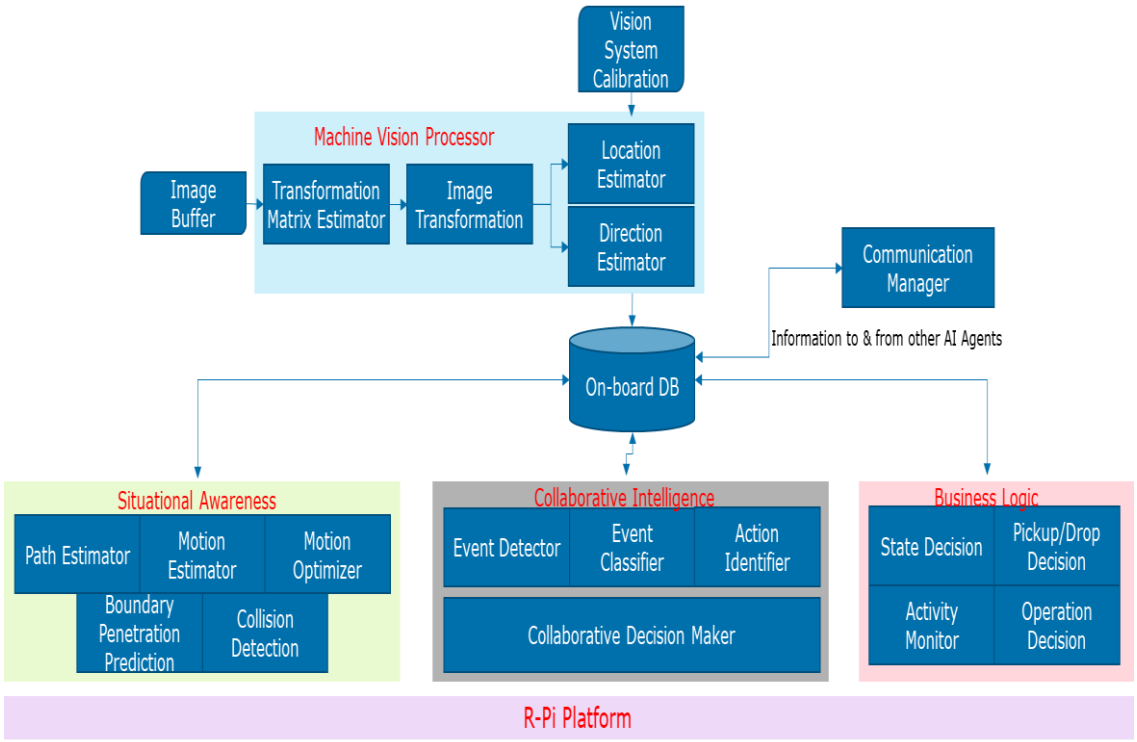

Figure 6: System architecture of HAWDI case study

4.3 ROBOT LOGICAL ARCHITECTURE

The various robotic operations include robotic vision, object

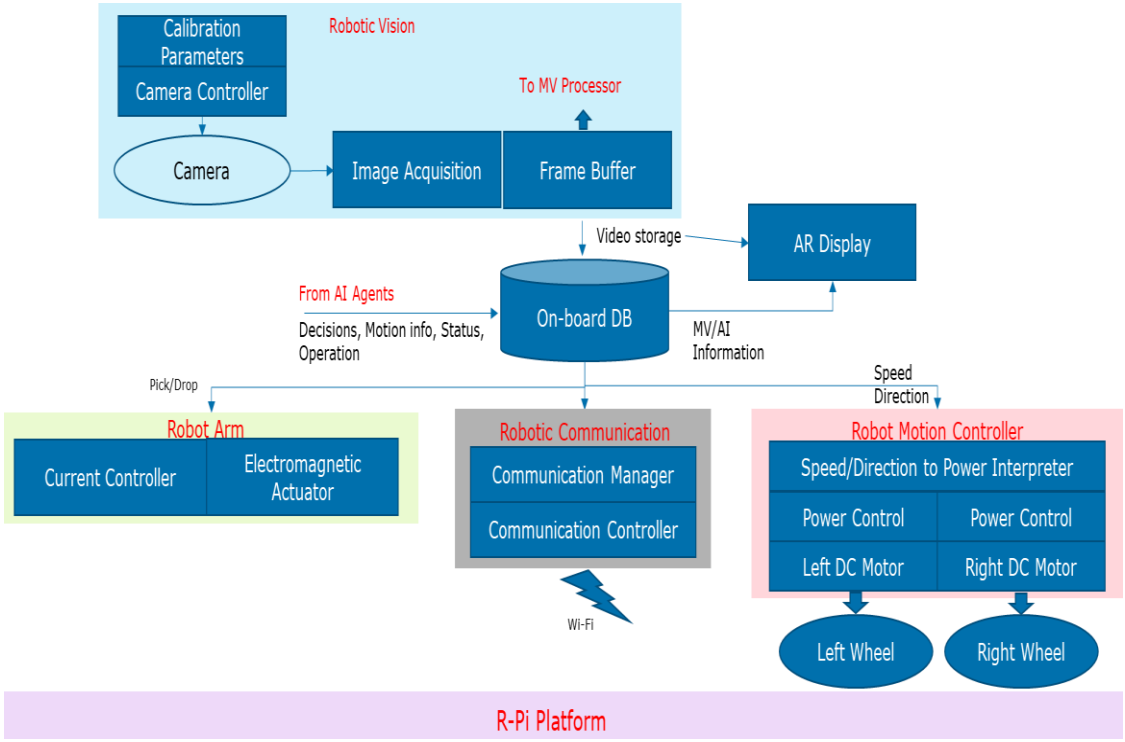

Figure 7: Logical robot architecture of HAWDI case study

detection, zone detection, robot to robot communication, planar movements in horizontal workplace, and object pick-up/drop functionality.

Object picking is accomplished using an electromagnet installed on the robot. The logical architecture of robot is schematically presented in Fig. 7.

4.4 DEMO

The case study is illustrated through a set of robots working collaboratively and intelligently using *HAWDI* platform. Video demonstration is available at Engineering Analytics Knowledge Management portal.

5. OPPORTUNITY LANDSCAPE

As per Gartner [7], smart machines will enter mainstream adoption by 2021 and enterprises look to service providers to help deploy AI technologies.

THE NUMBER OF IOT FIELD DEVICES ARE EXPECTED TO RISE TO 50 BILLION BY 2020.

Markets & Markets, 2016

With growing number of Edge/IOT devices every day, the applications of democratized AI cut across multiple sectors.

5.1 MANUFACTURING INDUSTRY

Material movement is so common in many industries. For instance, hot-rolled coiled sheets or heavy casted ingots in steel plants. The industrial cranes used in this context are usually manual-controlled and demands lot of

coordination with shop floor personnel. Number of incidents do occur on daily basis while mobilizing such heavy and hot products from one place to other place within the plant. A fully situationally aware, intelligent and collaborative AI solution is required here. This will not only improve productivity but also enhance human and machine safety as well.

5.2 MINING INDUSTRY

Autonomous haul trucks in mining industry are self-driving but remotely monitored by operators (from a central control room) who continuously watch number of displays and frequently communicating with personnel in


Courtesy: Forbes

the pit. These vehicles, by being driverless, surely eliminated the accidents [8] caused by fatigued drivers but there is still good scope of improving productivity by making operations more autonomous. This can be achieved by establishing direct collaboration between haul trucks, shovels, and other mining vehicles.

5.3 AUTOMOTIVE & TRANSPORTATION

High availability is very important particularly with respect to fleet management and goods transportation. For example, when a truck carrying certain goods is broken down on its way, most often currently, the alternative is assigned by a central control station which impacts delivery times. By employing collaborative


Courtesy: Forbes

intelligence model, the goods can be transported faster directly by another truck which is in vicinity of the delivery location. In the similar lines, connected cabs and courier services are the other potential application areas.

5.4 HEALTHCARE

The use of AI in health care is growing recently – from managing medical records to suggesting medication to assisting doctors in surgeries [9]. To mention one, nursing is one such area which involves continuous monitoring of patient at times and, consultation with doctors when situation turns critical. Many a time, due to 24/7

availability requirement, human errors are inevitable in such scenarios. Virtual nursing


Courtesy: AITrends

assistants are not yet matured enough to handle things autonomously at this stage. An AI agent should be able to seamlessly monitor/sense the health parameters of the patient, assess the criticality, and should coordinate with the doctors or other AI agents for the necessary action or intervention.

5.5 OTHERS

In the above sections, few key problems in certain sectors are only highlighted. Needless to mention, there are further potential opportunities in other areas. For instance, in the context of Smart Cities [10], there is scope for implementing the collaborative intelligence solutions with respect to Vehicular Traffic Control, Public Parking, and Building Automation.

6. CONCLUSION

The use of decentralized architecture in Artificial Intelligence applications is going to become more prevalent and most likely inevitable in future due to inherent advantages of faster decision-making ability and lesser dependencies.

It is illustrated with a warehouse forklifting example how our *HAWDI* platform enables mobile robots that are fully situational aware about the workspace and each other using machine-vision and machine-learning, auto–provisioning the work areas and helping each other in case of outages in a completely distributed and collaborative environment.

This demonstration emphasizes the potential of democratized intelligence in achieving larger goals with limited/constrained capabilities in a group, which otherwise is not possible individually. It is indeed time to invest in this space and embark upon AI-as-a-Service model through platforms such as *HAWDI*.

7. KEY REFERENCES

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