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Robots + ROI:

The AI Dimension

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September 2019

Context

Robotics have evolved immensely over the years. Also, e-commerce along with scarcity of labor is creating an unprecedented demand for articulated robots, and in particular automated mobile robots. For potential customers, robots bring unprecedented benefits over traditional manufacturing and warehouse operations. However, the challenges associated with the robot deployments are multi-dimensional. Robotic vendors need to not only integrate the mechanical, electrical and other innovations in the latest designs, but also integrate a lot of the Artificial Intelligence developments to take care of exception scenarios that humans handle naturally. AI in this context requires integrating a wide range of machine learning techniques that span from symbolic and logic AI to the various instantiations of numerical AI.

The biggest barrier to Robotic deployment, despite all the advances, is the return on investment (ROI). AI has a potential to address the ROI challenges associated with Robot deployment. It brings in new challenges as well. We discuss the fundamentals of corresponding trade-offs in this paper, building a thesis along with that. We do so, based on our hands on involvement in the design and deployment of robots for specific industrial applications, integrating various AI models within that. Some of our experiences are summarized in this note.

Robots ROI Revisited

ROI, of course, is driven by the robot's purpose. The best way to illustrate the ROI logic is via a real world example, from the ones we have been involved with in terms of design, conception and deployment, and from which we can extrapolate some of the conclusions.

Typically it is common for robotic vendors to claim that they can replace a minimum wage human being. We can use the minimum wage as a baseline for our illustration, from which we explore how introducing AI extensively in the robots, gets factored into the ROI analysis. Within this specific scenario under consideration, the worker-replacement based value proposition alone caps the potential revenue per robot to the max of prevalent minimum wage. To earn that minimum wage the robotic vendor has to ensure:

1. The speed and accuracy of the robot is as high as human beings
2. The capability of the robot includes the ability to handle exceptions for the particular task similar to what a normal human worker would handle.

We believe that the only way the above can be achieved is through an extensive use of AI in Robots. The AI is not just the part of robot's task automation but is an integral piece throughout the operations cycle, from automation to diagnostic to support, among other things.

The first challenge is the speed of the robot which depends on the complexity of the job. As an example, consider a task that requires a human being to move a cup from one place to another. It can easily be generalized to include various types (size, shape, purpose) of cups, glasses, thermos etc. However, this simple generalization may be challenging for a robot without extensive AI capabilities. It will likely fail to pick many types of these

items without sound AI integration. However, introducing AI also potentially reduces the speed of the robot (note: this can be mitigated by high powered GPUs, playing into the cost trade-offs). Depending on the design of AI, the accuracy of robot will be a little sub par as compared to human beings. The reason is the exceptions that occur with day to day mundane tasks. Human beings adjust to the exceptions naturally whereas the robots, while much better than machine in terms of handling exceptions, are nowhere close to human beings. This can primarily be mitigated using extensive AI learning loop.

Following the logic of the same scenario: while it's easy to achieve an accuracy of 95%, reaching 99.99%+ accuracy for robots requires a lot of effort in terms of AI modeling, training and tuning. Adoption of AI in robots is the cornerstone of the ROI argument we would like to bring. The cost/accuracy of AI enabled robots can achieve a commercially viable ROI, justifying deployment at scale.

Building on our robot deployment example, the following scenario is also typical: Given the fact that robots would make mistakes, it is common for customers to deploy an overseer (associate) for robots on the floor. The number of people needed to oversee the robot farm depends on the accuracy and intervention needs of the robots. A good number is to have one person manage 10 robots but often times its 1 person managing 5 robots. This means that the lack of good AI reduces the potential revenue by 20%. Furthermore, mitigating some of the potential robotic halts will require the robotic vendor to remotely manage a robot: reboot, restart or request an onsite person help to get the robot reengaged in the production pipeline. If one person at vendor site manages 10 robots, then the vendor cost for managing the robot fleet increases by 10%. This further highlights the need of comprehensive AI needs for Robotic operation..

From the above example we show that a robot may earn only about 68% of the Minimum wage. Robot Earnings = Minimum wage * 0.85 (low speed and accuracy) *0.8 (on site help needed) that equates to 68%. Here again, the approach to reduce the human intervention and hence associated costs requires embedding more intelligence in robots. Furthermore, robots performance monitoring would be required to identify and accelerate learning loop, which again, calls for analyzing its respective AI modeling, learning and tuning cost tradeoffs.

There are more overheads in terms of power and bandwidth needs so it's a good thumb rule to assume 50% of the minimum wage per robot. This means a robot working for 16 to 20 hours will typically provide the customer of the robot an equivalent ROI of one person in 8 hours. Currently, we are ignoring all the security needs, such as human access to robot and management of robot introduced contamination / risk, to keep the math simple. The security implications of robotic deployments will be covered in another paper where we discuss how AI can help with security, from denial of service to intrusion detection to software vulnerabilities management.

From the above calculations we can deduce that even if the robot is fully utilized (20 hrs a day, about 250 days a year), it can barely earn $50K a year with fully loaded minimum

wage of $20 (Robot will get paid $10 per hour based on our 50% overhead explained above). Most places, the fully loaded salaries are closer to $15 so the net revenue is going to be less. This lost revenue due to errors from exception handling, speed loss, operator and associate overhead can be significantly reduced by a properly designed AI solution.

There are in fact more challenges. Usually, no single repetitive task that robot replaces has consistent demand. Generally the tasks are seasonal. For a few months, the warehouse is extremely busy and for other months it's rarely busy. It's fair to assume that Robots will not be utilized about 50% of the time. Thus the take home pay for robot gets further reduced to $25K in the above example. A general purpose AI based solution can help repurpose the robot for different tasks to mitigate the underutilization scenario.

Given the high upfront cost of the Robot and uneven utilization, it is now common for customers to pay Robot vendor on a pay-per-use model, which is a model that is fast becoming the norm.

If the robot vendor wants to recover the money of hardware in about one year then the cost of the Robot should not exceed $25K (even with our simple calculation which ignore the costs associated with power, bandwidth, security etc). Depending on the sensors, electronics , arms and mechanicals ; the cost of the robot can be much higher. The burden on Robotic vendor (aside from the user of the robot such as manufacturing facility or warehouse) needs to include breakages, operational overhead of monitoring robot by vendors, customer support, training, software upgrades etc. So the cost to Robot vendor is lot higher than just the Bill of Material.

Most of these aspects are today addressed by the inclusion of artificial intelligence models in the lifecycle of the robots design and deployment. All of these AI models call for factoring in associated costs at every level of their design and deployment. Hence the robot vendors are forced to provide high value for very low return. The ROI math makes it tough for robotic vendors to innovate until they can bring the cost down significantly, and having full control on the AI integration dimension becomes primordial.

Robot ROI: Further into the AI dimension

There are however strong mitigation factors that we have not yet discussed, and the macro economics are likely to play in their favor over time, specifically in certain industries and certain regions of the world. These are

1. Increased predictability of Robot
2. Increased Labor Shortage
3. Increasing minimum wages

Robots are always on time. They do their work diligently 20 hours a day. Their performance is also quite uniform throughout the day. That can hardly be said for a human being. It is often common to compare the best of human beings with the average performance of a robot. This is not a correct measure. The real measure of the ROI is to include lot more overhead such as hiring expense, management expense and sustained throughout over

a long time. All of a sudden the robots start looking appealing to the customers, when deployed for specific industrial applications.

Labor shortage in critical areas, or during peak season makes the end-user experience difficult to manage. In this competitive world, manufacturing unit or warehouse operator has no choice but to include robots as part of their operations to provide the experience expected from their consumers.

Furthermore, minimum wages are increasing rapidly while the price of Robots tend to go down as more people adapt Robots.

These aspects will over time, increase the ROI for robots deployments, and in conjunction with progressively embedding more AI functionalities, will strengthen the business case for deployments, in many more new areas.

Hence, net net, while it is true that the robotic industry has yet to overcome the ROI challenge, nevertheless it appears to be closing the gap rapidly. Advancements in AI and its rapid incorporation in robot will drive the robotic revolution for next many years.

Conclusion

We revisited the Robots deployment ROI dimension, via an illustrative use case, which through extrapolation, allows us to firm up the following thesis: Robots need to hit very stringent KPIs to make them economically viable. This has led to various false starts in deploying robots. One of the fundamental answers to achieving these KPIs is the need for embedding more and more advanced AI-enabled designs into robots. The caveat is that it requires clear understanding of AI costs, limitations and trade-offs versus benefits. Over time, economics will likely play into strengthening the ROI for robots, but the AI tradeoffs dimension will remain the cornerstone of such ROI equation. The AI dimension integration into robots is one that we have extensively worked on, and applied in real world scenarios. This will be the focus on another discussion paper.

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