Analytics in the Age of Digital Transformation

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In digital transformation, the “third platform,” which is to be the foundation of new products/services, new business models and new relationships, is said to consist of four pillars – “cloud,” “big data & analytics,” “social business” and “mobile”[1].

This article describes OKI's efforts focusing on the analytics related to analysis/utilization of big data and the technical means such as AI (Artificial Intelligence). Particularly the reason behind these technologies’ focused attention, the necessary technical requirements, corresponding technical system and applicability to various fields including examples of practical applications will be explained in the context of digital transformation.

Digital Transformation and Data Analysis / Utilization Technologies

Thanks to the progress of digital transformation, what has previously been difficult to acquire as digital data can be acquired as big data.

The data gathered due to digital transformation are big in terms of the three V’s - Volume, Variety, and Velocity that define big data. Furthermore, if the data are well utilized, impact in terms of Value will also be big, thus can be referred to as the true big data.

If data is regarded as a new resource for business operation equivalent to people, goods and money, then the amount of data gathered, analyzed and utilized will be the future source of competitive power for businesses regardless of industry.

Data analysis/utilization technologies and activities that discover valuable patterns from data and support decision-making are collectively referred to as "analytics". The idea of this "analytics" is largely divided into three types as shown in **Figure 1**.

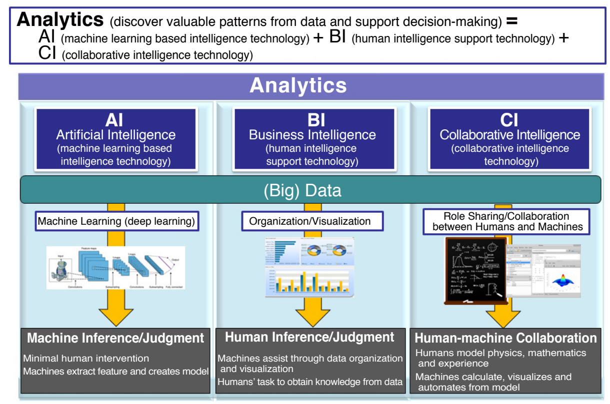

Figure 1. Types of Data Analysis/Utilization Technologies

“AI (Artificial Intelligence)” is drawing particular attention and is becoming the main force among the three analytic types. With manual analysis alone, it is often difficult to extract knowledge and value immediately from the gathered big data due to the characteristics of the aforementioned three V’s. When large volumes of real-time data constantly flow like flood waters from various kinds of device embedded in every part of society, obtaining useful information from the data far exceeds the scope of human understanding. Against such a background, particularly high interest and expectation is given to machine learning based AI such as deep learning in which the machine automatically extract features from data.

Techniques used in analytics are not limited to inferences and judgments performed by machines.

With “BI (Business Intelligence),” humans are at the center. Machines organize and visualize data while humans view the results to make inferences and judgments. This allows the utilization of on-site knowledge and business expertise. However, since the method relies on humans, efficiency is generally poor and whether truly good inference or judgment can be made depends heavily on the person performing the task.

In “CI (Collaborative Intelligence),” the right person/machine at the right place and role sharing approach is taken. That is, humans model mathematics, physics and experience, and machines perform computation and execution. With CI, the basic model is human-understandable and explainable, and its advantage is that it can be implemented without sufficient data. Meanwhile, modeling by humans is the biggest problem, and it is inappropriate when there is no mathematical structure or physical principle in the background or when dealing with complicated relationships of various data.

Generally, in order for AI based on machine learning to work fully, a large volume of appropriately organized data is required. However, in the real world, there is often not enough necessary and sufficient data to make machine learning based AI or to make it function effectively. If digital transformation progresses, such things will gradually be solved, but BI or CI that has human intervention will likely be used together for at least some time. In addition, depending on the application, BI or CI is selected to allow explanation or traceability at least to some extent rather than machine learning based AI, which is prone to excessive black boxing that prevents humans from understanding the inference and execution processes.

AI/BI/CI each has its advantages and disadvantages, and none can be said it is discriminately superior to the others. In many cases, proper use and combination are carried out according to purpose and use.

Technical Requirements and Technical System for Supporting Digital Transformation

In the digital transformation age, various technologies for data analysis/utilization are required in each process of collecting data, analyzing the data and executing based on the data. **Figure 2** shows the technical system that is considered necessary for realization.

The technologies in the white rectangles at the center of the figure are a group of basic technologies used commonly to support digital transformation.

It may be necessary to make proprietary expansion or devisal to these technologies, but in many cases, existing technologies or packages can be used, thus explanation is omitted in this article.

The orange rectangles represent OKI's proprietary and expert technologies within each process.

The requirements for each process of recognition/identification -> prediction -> execution in **Figure 2** and R&D that is being carried out to provide the proprietary/expert technologies are described in the following section.

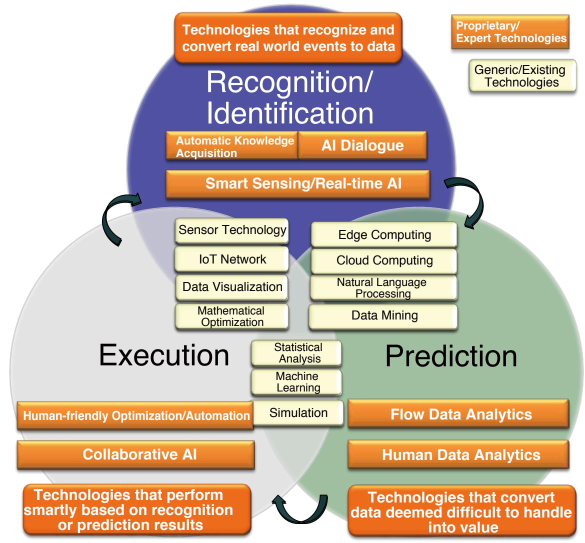

Figure 2. Technical System Required for Data Analysis/Utilization

(1) Recognition/Identification

Translating the 0/1 of digital data obtained from sensors into a form that can be processed by humans or machines is the requirement.

For example, in the supporting "smart sensing" technology, people and objects are recognized with high degree of accuracy even from images acquired under adverse conditions [2], and highly accurate data that were once difficult to obtain are acquired using various sensing methods such as sound waves, optical fibers and lasers [3][4]. "Real-time AI" that recognizes events in real-time from fresh data is also important as a supporting technology.

Efficiently eliciting information from people is also an important technical task. For this, there are proven track records using text analysis technology to extract useful knowledge from natural language data (e.g. conversation records, various documents) and stepwise question and answer of "AI dialogue" technology to elicit information naturally yet efficiently from people [5]. In addition, "automatic knowledge acquisition," which (semi) automatically acquires the relationship between concepts and uses it for semantic understanding, is also considered a technology requiring R&D focus and is being strengthened.

(2) Prediction

Here, the requirement is to predict the future or occurrence of anomalies from the acquired data. Discovering patterns from data is the basis of the technology, but OKI's strength lies in predicting/estimating from data that was considered particularly difficult to deal with in the past.

For example, equipment's operation log or data dealing with "flow," such as traffic, communications and rivers, are called "flow data", and they have been treated statistically for use in predictions and anomaly detections. Work on technologies to understand and predict "human data" that includes human behavior and feelings will also be undertaken.

(3) Execution

In this requirement, execution and control are demanded according to the predicted/estimated results.

Example technologies include mathematical optimization to optimize the number of lines from the predicted number of calls and automation to prepare a work shift roster. However, with AI alone, the optimization and automation results tend to be excessively strict. Therefore, the goal is to achieve "human-friendly optimization and automation" that leaves room to include human intuition and experience as well as the capability to adjust the degree of optimization.

Ultimately, it is expected that execution/control/optimization will not be a work of a single AI, but the collaboration and negotiation between multiple AIs or between humans and AIs. Looking forward to the future with "collaborative AI," studies have started to devise the necessary negotiation/adjustment mechanism and to address the various execution/control and systematical/legislative issues.

The results will be implemented in various terminals as a means to connect real with virtual and people with machines (AI equipped), making social infrastructure convenient and friendly to people.

Applicability of Data Analysis / Utilization Technologies

The applicability of the above-mentioned technologies to various fields and examples of specific applications are shown in **Figure 3**.

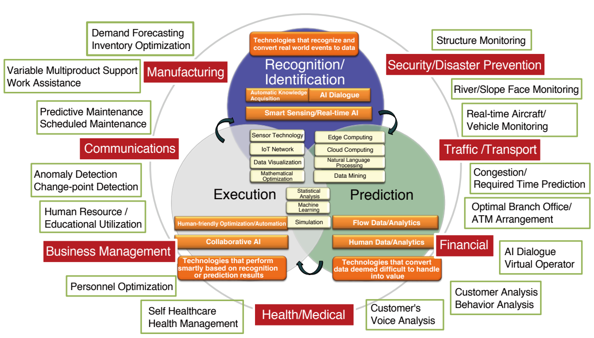

Figure 3. Applicability of Data Analysis/ Utilization Technologies to Various Fields

The central part of the diagram is the technology groups from **Figure 2**. Examples of applications that are made possible by applying these technologies to various fields such as manufacturing, security/disaster prevention, traffic/transport, finance and business management are arranged outside the outer circle.

Many of the applications are not field specific and can be applied to other fields as well. For example, when "anomaly detection" is applied to communication, it is likely used in the security area, but in finance or business management, it can be applied to detect fraud when abnormal transactions or behaviors occur. Other applications, such as AI dialogue, have potential for usage in wide range of fields.

Application Examples of Data Analysis / Utilization Technologies

Table 1 shows some practical application examples of data analysis/utilization technologies aimed at advanced business processes.

In all cases, acquisition of accurate and high precision digital data is a prerequisite for success. Accurately grasping data that could not be previously acquired is the key in the digital transformation age, and this is where OKI's technologies thrive.

BI and CI that utilize on-site knowledge or models made by humans were more suitable in some cases rather than black-boxed AI using deep learning. However, this is not a complete renouncement of AI. If there is a part that can be explained mathematically or physically, CI approach is used, and it is possible to use a hybrid approach in which there are human adjustable parameters and AI is used to set those parameters. When using such a method, the kind of efficiency possible with an all AI approach is not attainable. On the other hand, if expected precision is not achieved, derivation principle can be traced to explore the cause making it easier to devise improvements or explain to customers.

In some cases, support in the prediction and execution phases was not sought, and primary focus was on supporting human recognition and identification with a BI approach.

Primarily, analytics is aimed at obtaining knowledge and results that are useful for business regardless of its methods. Comprehensive evaluation (including whether business objectives can be fulfilled or sufficient investment benefits can be attained) and wisdom of usage are essential. Knowledge and expertise with regard to these points are constantly accumulated, and systematization and solutions are being pursued.

Table 1. Application Examples of Data Analysis/Utilization Technologies

Application	Description	Application Categories			AI/BI/CI	Used Data (Example)	Provided Value
		Recognition/ Identification	Prediction	Execution			
Personnel Optimization	Predict future number of calls per day/time period from number of calls in the past. Based on this, automatically create a shift roster that takes into account a certain service level, staff availability, holiday/night shifts, etc.	○ Recognize call volume/ response time from reception system	○ Predict call volume	○ Create optimized shift roster	CI+BI Partial AI	•Reception system log •Shift request table	Automate cumbersome task of creating a shift roster. Also ensures fairness in assigning holiday/night shifts.
Checkout Congestion Prediction	Measure/visualize the number of people/attributes at entrances or checkout counters of shopping centers and predict congestion to optimize staffing and minimize wait time at checkout.	○ Recognize number of waiting people/ attributes through image recognition	○ Predict checkout congestion	○ Optimize opening/ closing of checkout counters	AI+BI+CI	•Visitor attributes •Recognition of number of customers at checkout •Opened/closed checkout info	Visualizes checkout congestion, optimizes staffing and minimizes checkout time.
Material Demand Prediction	Records of past orders are applied to multiple prediction models and optimum order quantity is predicted to minimize inventory overage/shortage.	○ Classify materials from order trends	○ Predict order quantity		CI	•Order record •Inventory •Number of operating units	Data and on-site intuition/ experience combination supports and optimizes ordering work to prevent excessive inventory and material shortage.
River Water Level Prediction	Based on a 3-stage tank model, statistical approach is used to learn parameters from data taken at rainfall and river water level sensors installed in basins of medium and small rivers. Then, river water levels and flood risks for the next 30 minutes to 3 hours are accurately predicted.	○ Recognize flood risks from predicted water level	○ Predict water levels	○ Dispatch evacuation notices based on flood risks	CI+AI	•River water level •Rainfall amount • (Rainfall prediction) •Basin area •River extension/ Gradient	Protects human life/property and provides sense of security through delivery of early evacuation notices.
Advanced Maintenance (Predictive Maintenance)	Relationship between defect occurrence of past equipment and maintenance activities is analyzed to obtain the probability of maintenance necessity against defect occurrence. Then, maintenance timing and work content are optimized.	○ Recognize the need for maintenance			CI+BI	•Defect occurrence log •Maintenance activity record	Optimizes maintenance timing and reduces unnecessary maintenance activities.
ATM Placement Optimization	Visualize actual usage of ATM taking into consideration user distribution and surrounding environment around the ATM, and use it for placement strategy.	○ Utilization rate taking into consideration surrounding environment of ATM		○ Optimize ATM placement	CI+BI	•ATM transaction volume (estimated) •User distribution •Census data •Map data	Quantitatively grasp the utilization status of ATM and make use of it in deployment and placement strategy.
Call Analysis	Automatically classify text data describing customer inquiries to the call center into multiple classification axes.	○ Automatic classification of inquires			AI+BI	•Text data describing inquiry contents	Reflect to FAQ and manual, improve responsiveness and reflect customer opinion to new product planning.
Virtual Operator (Automatic Response System)	Initial response to call center inquiries are automatically handled using the dialog engine.	○ Understanding intent of inquiry	○ Surmising customer's situation and needs	○ Resolving customer's problems and needs	AI	•Text data of customer response to the various questions from the dialog engine	Automatic responses to relatively simple inquiries reduce labor cost and allow 24-hour operation.

Future Prospects

OKI's present ideas and efforts in data analysis/ utilization technologies, one of the technologies that support the realization of digital transformation, were discussed mainly from the R&D viewpoint of supporting technologies.

Changes in technological innovation and customer demands in this field are very fierce. In order to realize customers' digital transformation, not only technical excellence, but also co-creation through close partnership with people in each industry and integrated effort that combines OKI group's total power will be necessary. ◆◆

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