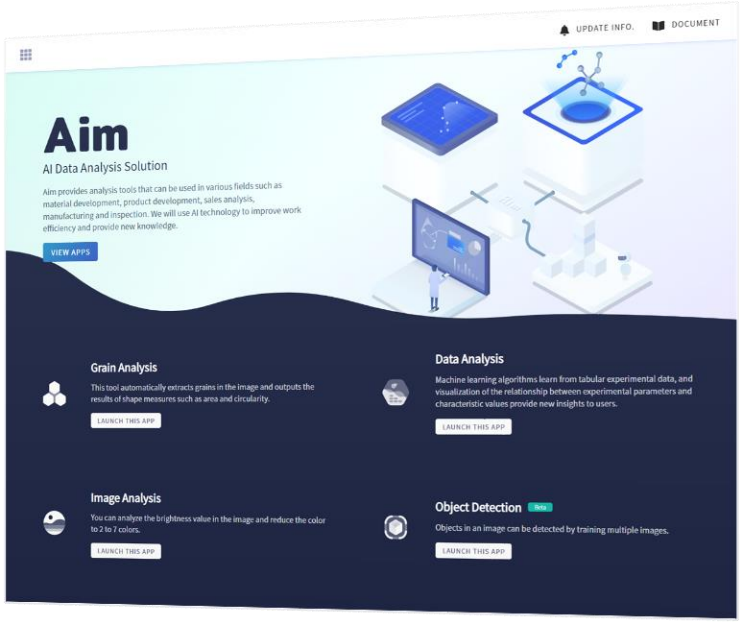
Attracting Tomorrow

Materials Informatics (MI) by building original AI data analysis platform



What is MI(Materials Informatics) ?

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… MI is a tool for materials development

10^9 Number of known materials

10^{62} Number of unknown materials*)

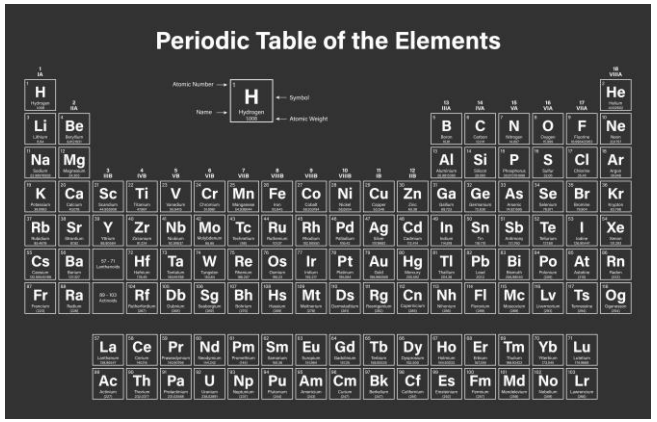
composition

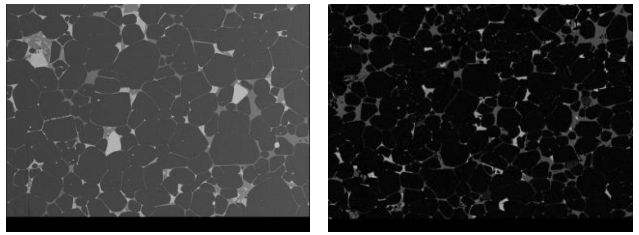
×

process

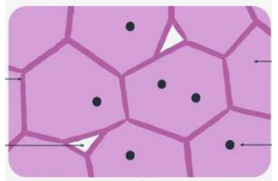
×

microstructure





data



scientific paper

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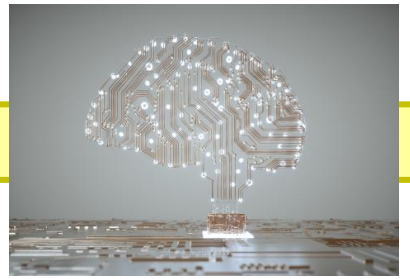
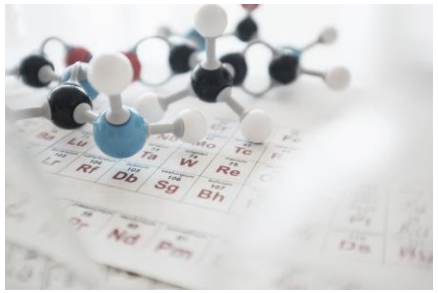
MI



New materials



"Materials Technology" × "Information Technology"

-> Materials Informatics

Rational material design is essential to develop the desired material from a myriad of candidates.

Rational design of materials can be performed by utilizing MI.

*) Y. Orii, et. al., J. Photopolym, Sci. Technol., 34 41 (2021)

Overview of TDK's MI

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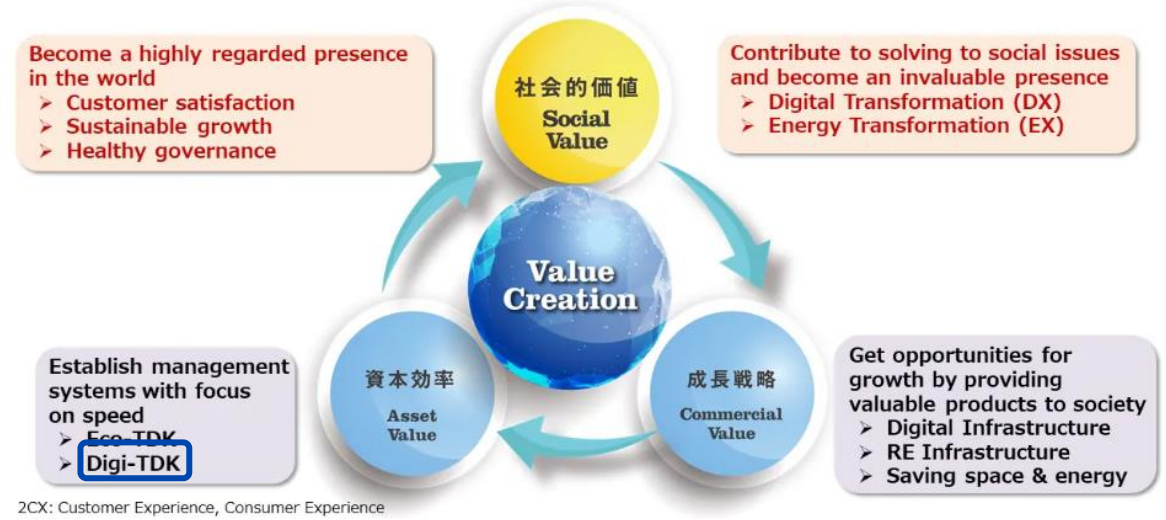
Company Profile 2022

Value Creation Cycle

Medium-Term Plan

~Accelerate DX and EX in order to realize 2CX and create value for a sustainable society



2CX: Customer Experience, Consumer Experience

TDK's Desired Digital Management

Annual Report 2020

Increased management efficiency through the utilization

- **Digital marketing**
  - Timely supply of product information and discovery of potential customers through the utilization of big data
- **Operations (sales, production planning, logistics)**
  - Digitally linking separated operations and creating inter-operation synergy
- **Acceleration of development (AI/materials informatics)**
  - Shortening of development periods through the utilization of AI and simulation
- **Promotion of Industry 4.0**
  - Improvement of productivity through the utilization of manufacturing execution systems and realization of zero defect
- **Standardization and increased efficiency of work (robotic process automation/shared services)**
  - Higher added value of work by promoting work digitization ⇒ Human resource skill improvement

Aim to realize 2CX (Customer Experience, Consumer Experience) through further enhancement of Materials Technology

Materials Development Flowchart

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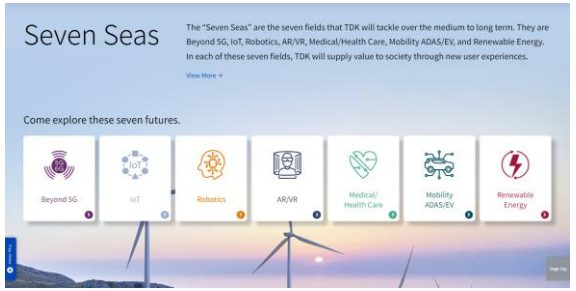
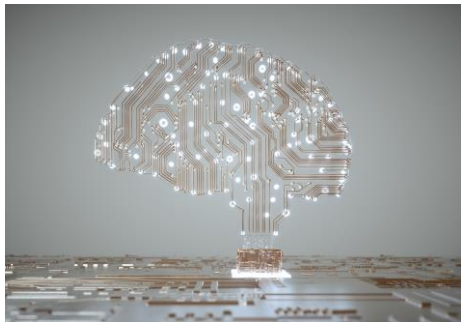


idea

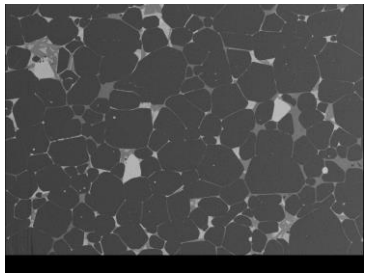
scientific paper

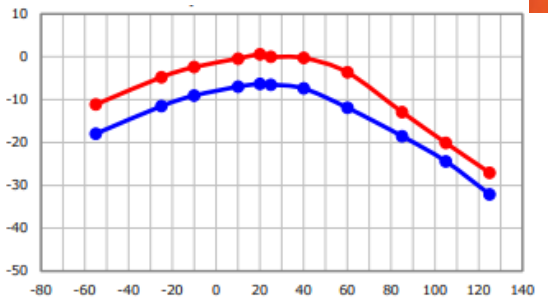
making

Data analysis



measuring





MI initiatives to Data

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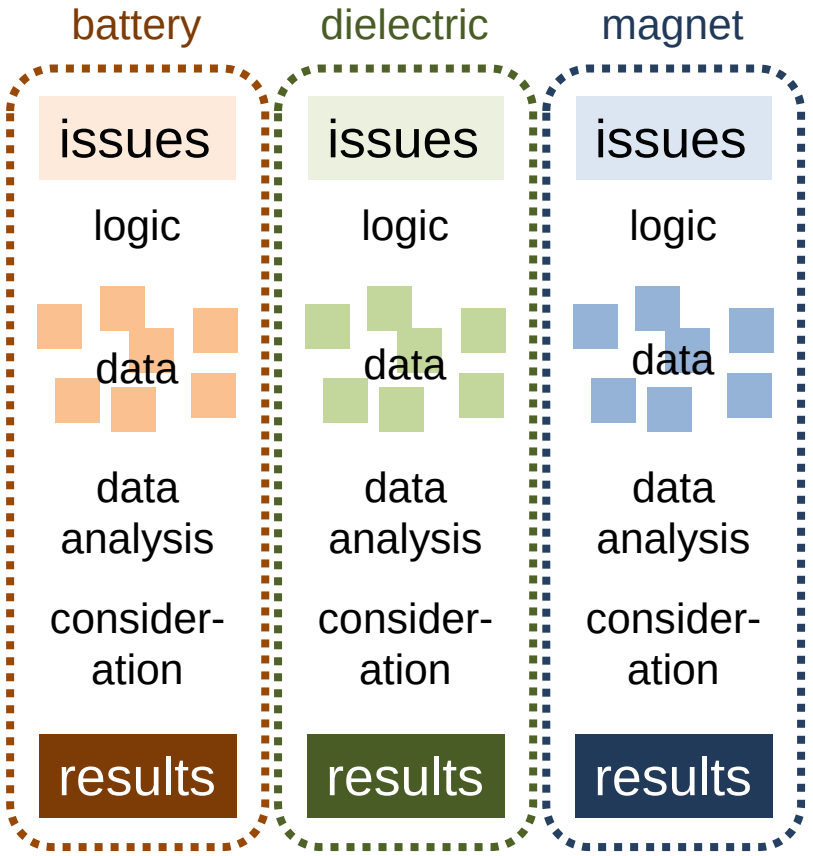
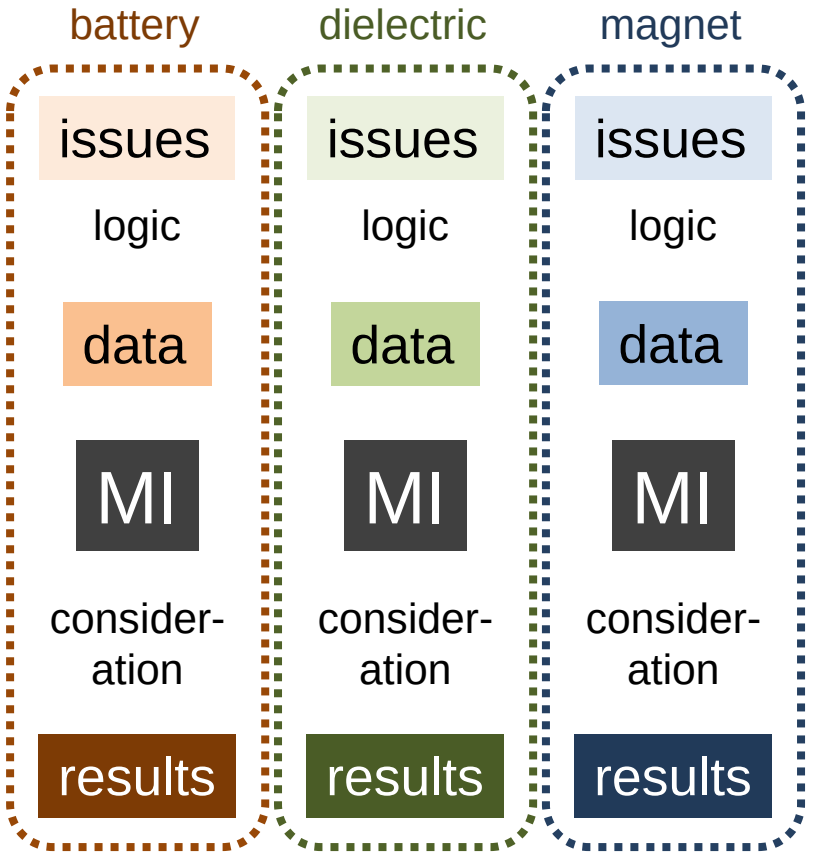
conventional (Step0)



The data is analyzed based on the knowledge and expertise of materials engineer.

current (Step1)



More advanced data analysis with MI
Maximize the use of data for materials development

Past results related to MI

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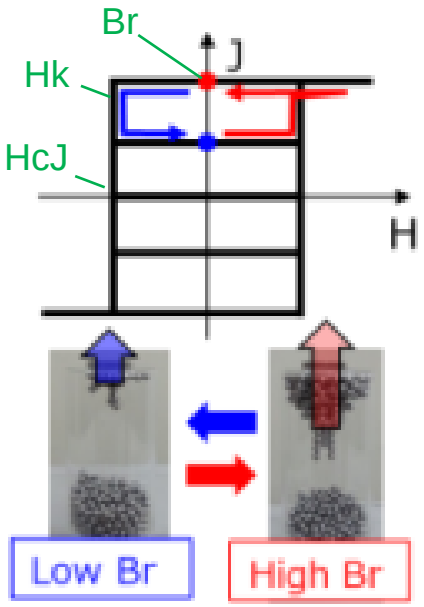
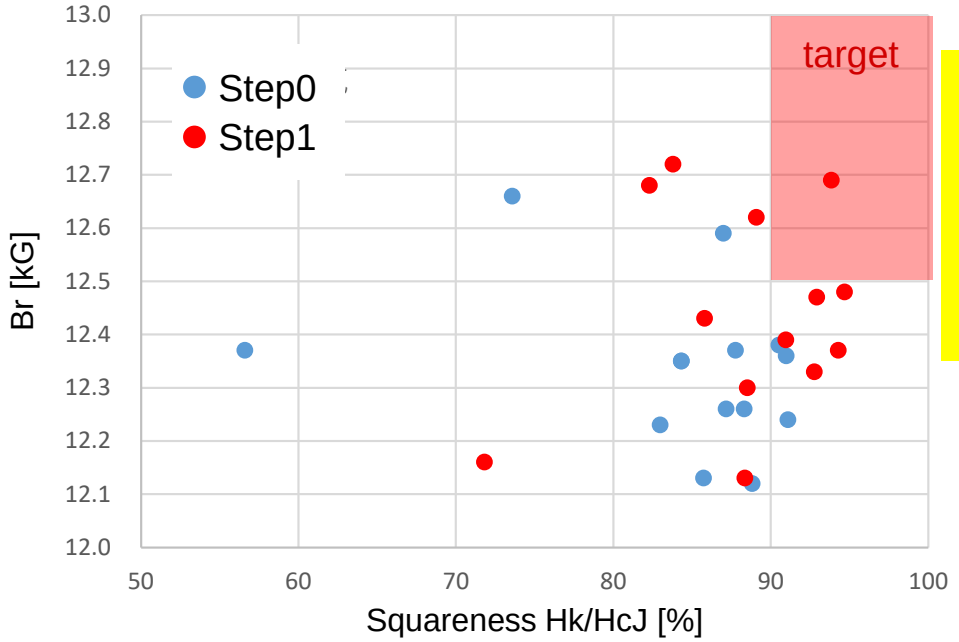
case 1 ： Application of MI to magnet material development（in 2018）

Variable Flex Magnet

Required high Flux density (Br) and squareness (Hk/HcJ)





Result：
Discovered high performance materials that could not be obtained from conventional human knowledge

experiment

data /modified data

367 records

machine learning

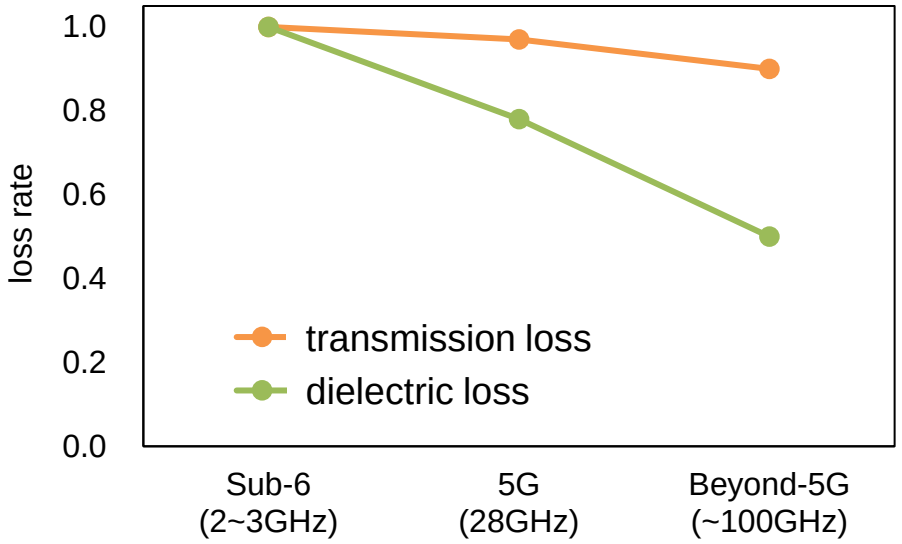
Programmed in TDK

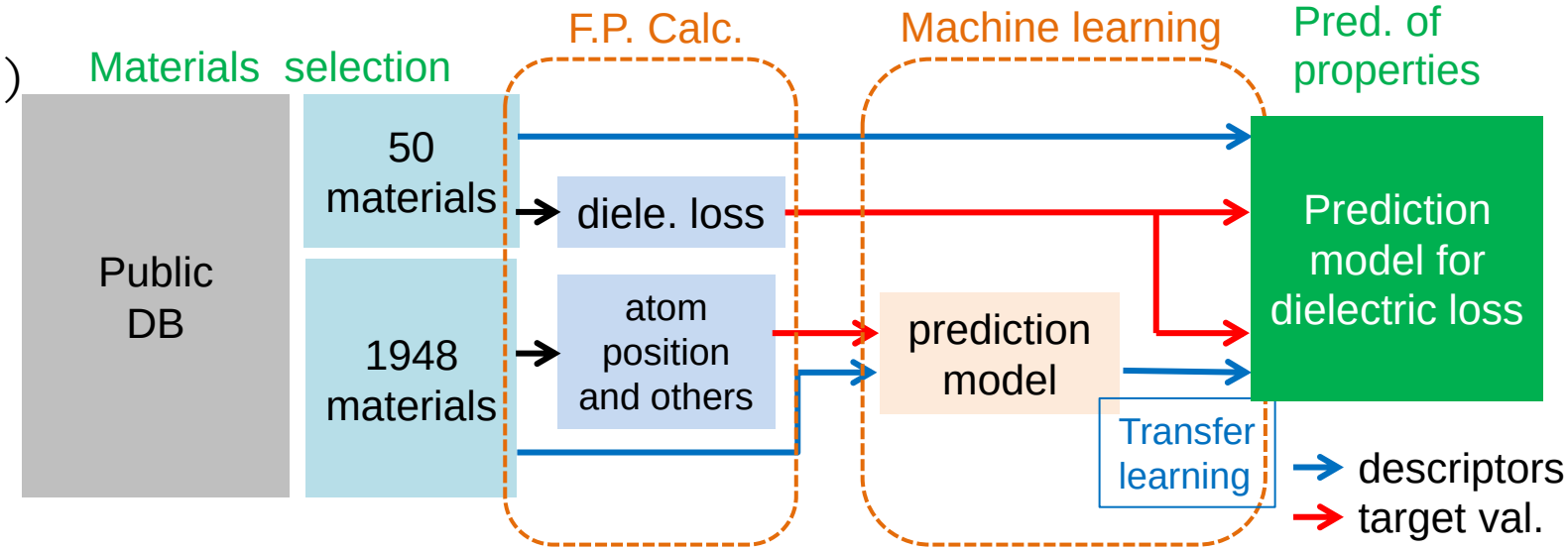
experiment

Past results related to MI

Attracting Tomorrow TDK

case 2 ： Application of MI to dielectric material development（in 2021）





Experiment

High precision experiments are not possible

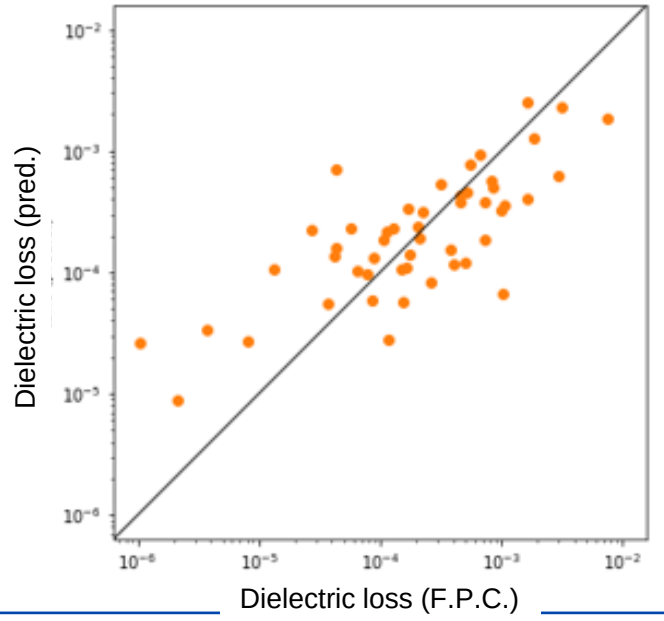
Simulation

Huge computational cost

Machine learning

Insufficient data

required a low-cost method to predict properties with high accuracy



Time required to predict loss of 2000 materials :

・by this method about 30 days

・by only F.P.C. about 2.5 years

Result：
Predictions that were virtually impossible to make can now be made.

Ideal MI initiatives

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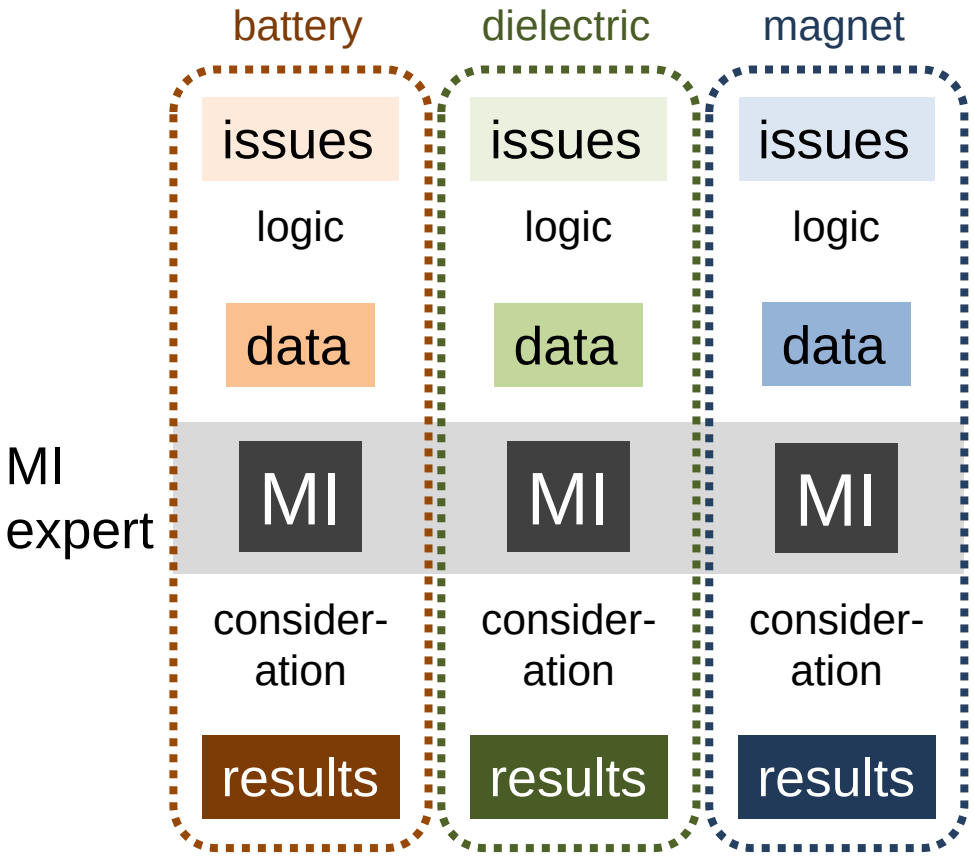
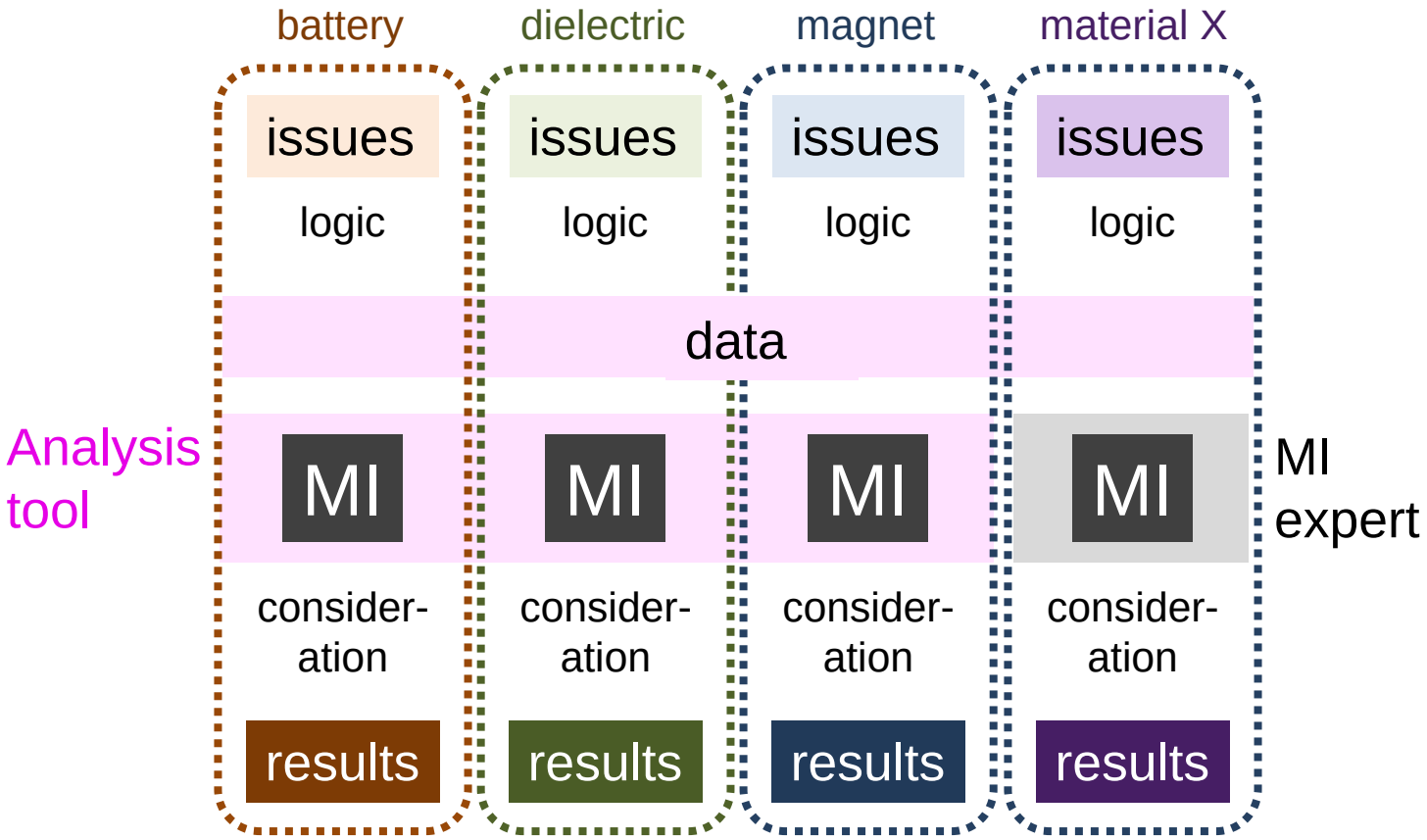
current (Step1)



Poor sharing of data and findings.
MI is performed by MI expert engineer.

from now on(Step2)



MI is performed by material engineers
Synergy creation through data sharing

AI data analysis platform “Aim”

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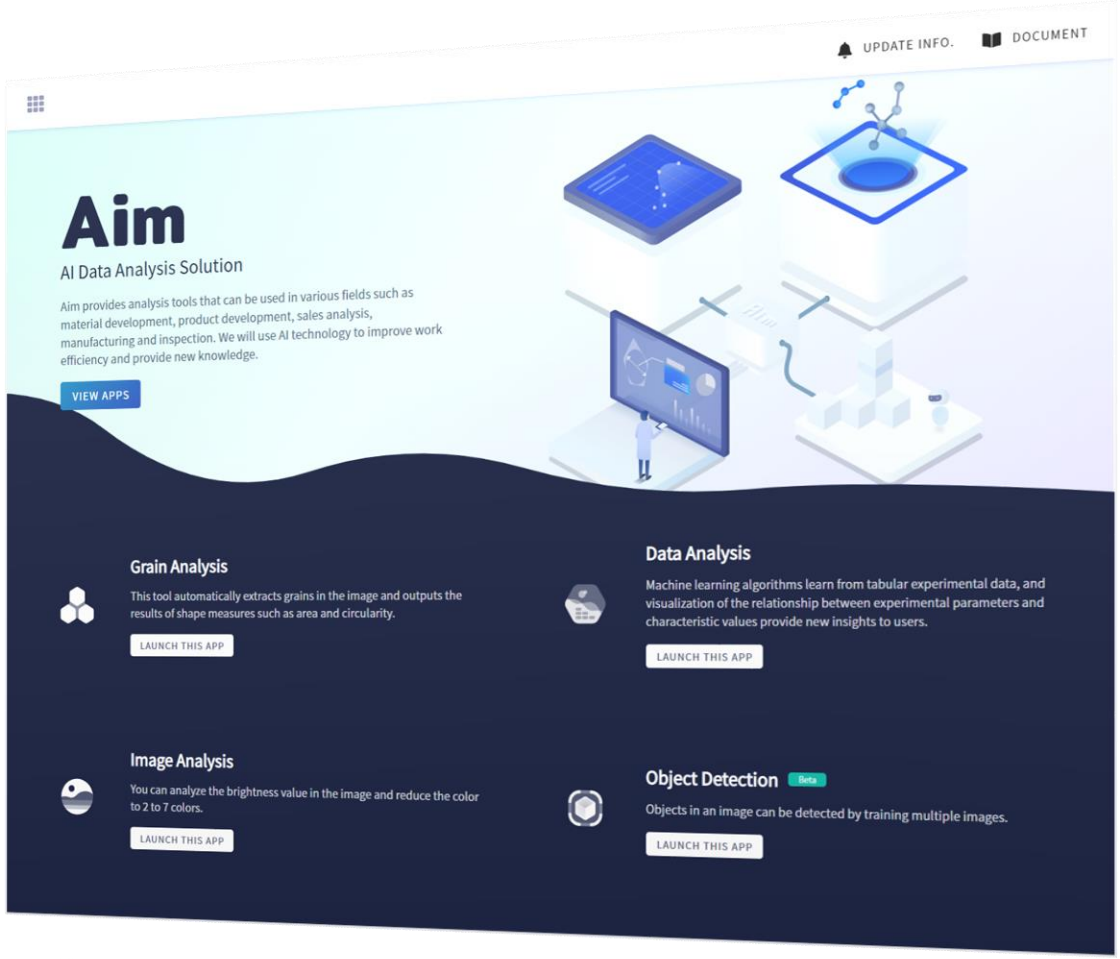
Aim AI DATA ANALYSIS SOLUTION **is …**

An original AI data analysis platform that was developed to widely deploy data analysis technologies accrued in individual departments throughout the company so that anyone can use them as well as compile high-quality data necessary for AI and big data utilization.



Features

Free	: For all TDK group employees.
Aggregated	: Data analysis technologies developed in TDK.
Customizable	: For individual needs.
Easy	: No installation needed.
Smart	: Batch processing of tedious procedures.

Development background future prospects

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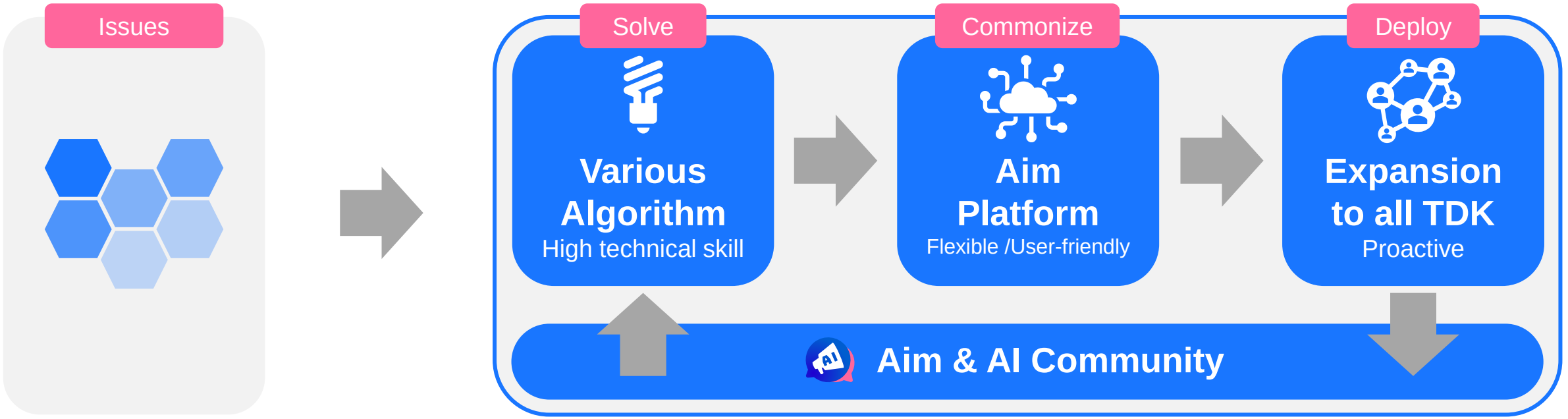
We would like to…

- Make the technologies and know-how developed through our leading efforts widely available.
- Create a mechanism for “data accumulation” using “data analysis” which is in particularly high demand.



We shall make the various technologies available in all TDK through Aim to achieve Digi-TDK.

Examples of use of Aim

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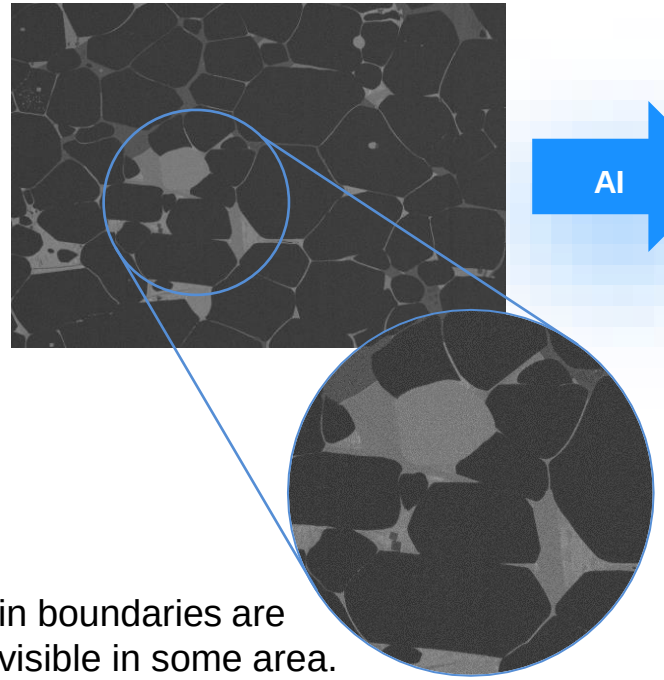
Grain analysis

High-precision extraction of numerical data that is usable for MI by focusing on grains.

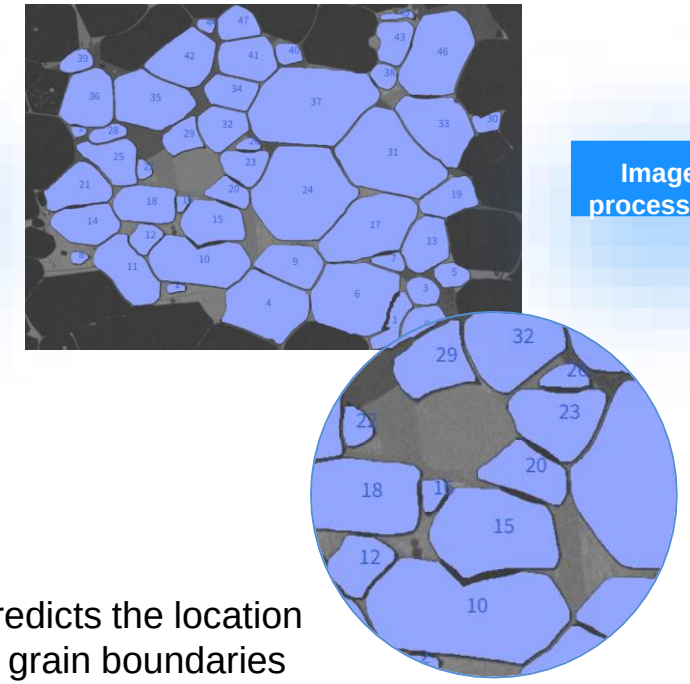
Input image



Grain boundaries are not visible in some area.

AI

Result image

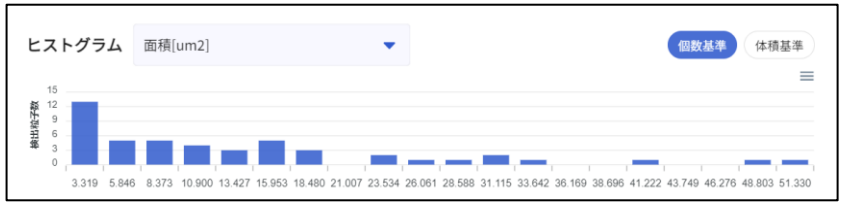


Predicts the location of grain boundaries based on the slightest clue.

Image processing

Result data

インデックス	面積[um2]	粒子座標X[px]	粒子座標Y[px]	周囲長[um]	円形度（Simple）	円
0	10.04	787	657	12.1	0.86	0.
1	5.9	722	649	14.2	0.37	0.
2	0.85	281	577	3.91	0.7	0.
3	4.74	784	584	8.34	0.86	0.
4	27.72	465	615	21.6	0.75	0.
5	4.35	842	551	8.17	0.82	0.
6	32.61	645	596	23.2	0.76	0.
7	2.69	719	524	7.33	0.63	0.



Analysis that used to take 30-60 minutes per image by hand can now be done in seconds.

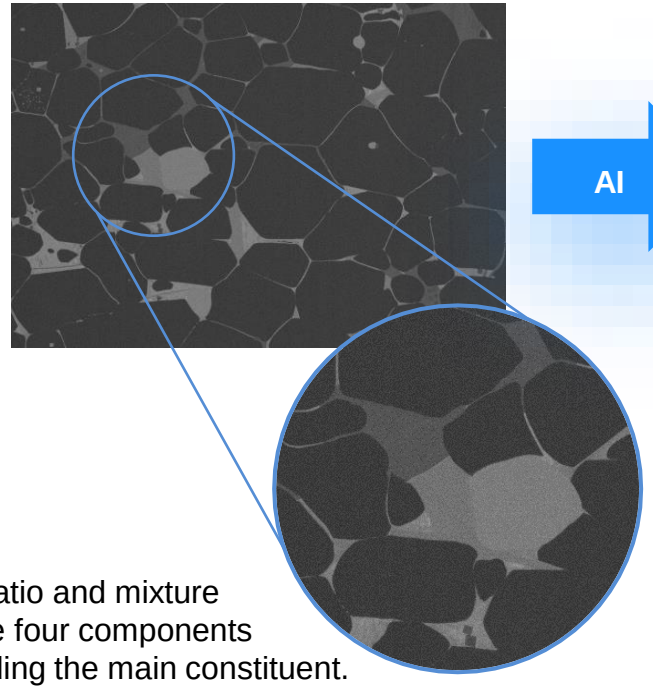
Examples of use of Aim

Attracting Tomorrow TDK

Image quantification

Extraction of numerical data from the entire image that is easy to use in MI.

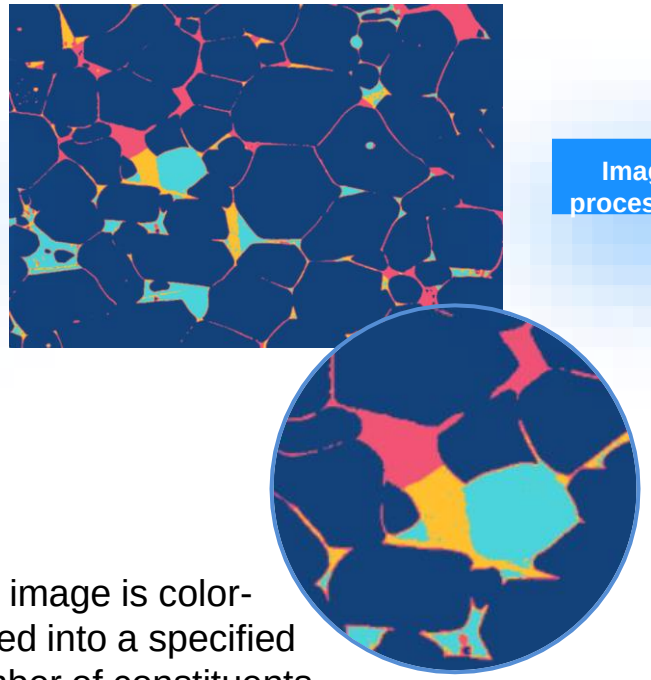
Input image



The ratio and mixture
Of the four components
Including the main constituent.

AI

Result image



The image is color-coded into a specified number of constituents.

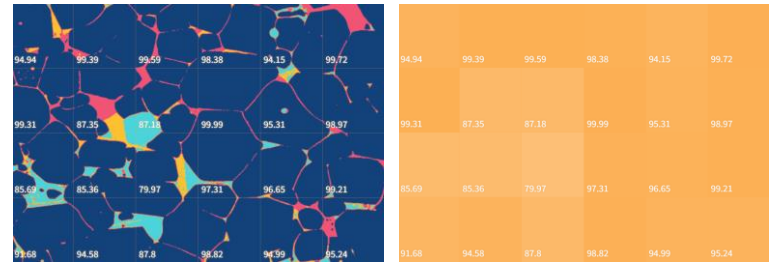
Image processing

Result data

Number of pixels and ratio of each constituent

1	634358 pixels	(88.6%)
2	40280 pixels	(5.6%)
3	16454 pixels	(2.3%)
4	24792 pixels	(3.5%)

Main constituent ratio of each parcel



Analysis can be performed from the viewpoints of other material developers, while minimizing the difference of analysis results due to human factors.

Image of material development using Aim

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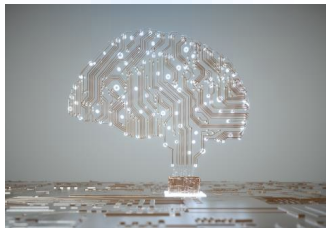
Input data

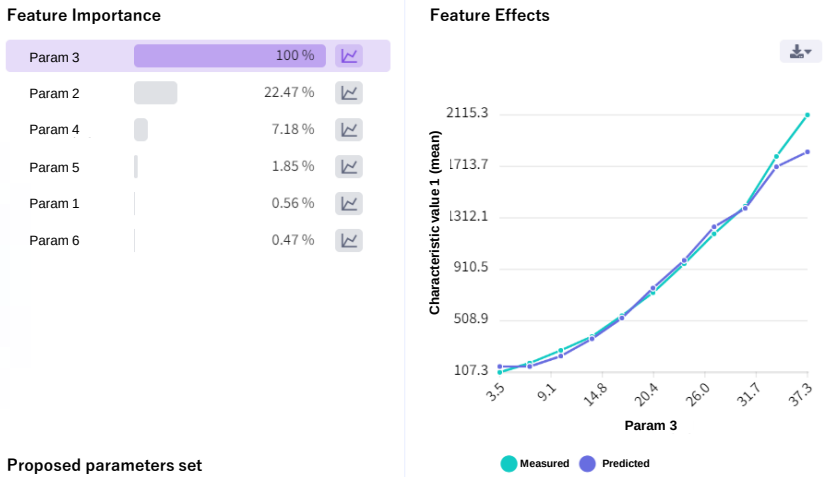
- Experimental data
- Image analysis Result data
- Simulation data
- Public data Literature data

Learning/Prediction

Insight/Awareness



Result



Proposed parameters set

Expected value	Param 4	Param 3	Param 5	Param 2
1461.8784977857313	29.9	34.5	26.5	891
2802.677497581408	30.8	35	27.2	1249
2465.527671889241	30.6	35.9	27.1	1154
2847.0608739897625	31.6	35.9	27.6	1263
1422.0589715073747	31.5	36.1	28.2	843
1724.9970999851294	24.6	29.7	22.2	1267
1652.1081739625015	23.8	27.7	21.6	1275

More objective data

More generalized analysis methods

Less different results from person to person

Prediction of experimental results can be done by using analysis procedures developed by skilled engineers, with numerical data including data obtained from images.

Future plan about MI

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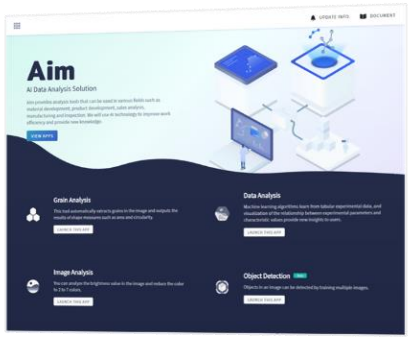
Data generation

Data sharing

Data Storage for Experiment

Data analysis

Aim
AI DATA ANALYSIS SOLUTION



Human resource development

Materials Development Support

User community

Continue activities to establish MI utilization

↓

Increasing use case of “Aim” for several issues
In-house production of AI analysis technology

↓

DX of development activities


TDK