Goldsmiths
UNIVERSITY OF LONDON

ICC/ 上海交大—南加州大学文化创意产业学院
USC-SJTU Institute of Cultural and Creative Industry

THE MUSEUMS + AI NETWORK

AI: A Museum Planning Toolkit
(Chinese Edition)

Dr Oonagh Murphy
Dr Elena Villaespesa

Chinese Partners:
Dr Emma Louise Duester
Ye Lin

Chinese Edition Published November 2024
doi.org/10.25602/GOLD.00037891

First published January 2020
By Goldsmiths, University of London,
New Cross
London SE14 6NW

Authored by:
Dr Oonagh Murphy, Goldsmiths, University of London
Dr Elena Villaespesa, Pratt Institute
Additional contributions by:
Luba Elliott, Emma Louise Duester, Ye Lin

Academic Partners:

The Network is funded by:

CONTENTS

Introduction	1
Chinese Context	2
Thinking about AI	4
Case studies	
The Palace Museum	6
The National Museum of China	8
Worksheets	
AI Capabilities Framework	10
Ethics Workflow	12
Stakeholders map	14
Glossary	16
Acknowledgements	20
Notes	22

INTRODUCTION

The Museums + AI Network was formed in 2019 by Dr Oonagh Murphy, Goldsmiths, University of London and Dr Elena Villaespesa, Pratt Institute, New York. The network was funded through the AHRC Research Networking Scheme and has brought together leading academics and museum professionals to critically examine current practice, challenges, and near future Artificial Intelligence (AI) technologies in both the United Kingdom and United States. The network has also engaged with more than 200 members of the public through events at Cooper Hewitt, Smithsonian Design Museum (New York) and The Barbican Centre (London).

Through these conversations, workshops, and public events we challenged current practice, engaged with wider critical technology discourse and iteratively developed a series of worksheets with professionals from 15 museums, and 6 universities in both countries. We also engaged with policy makers and funders to situate these development tools within a wider cultural policy context.

This toolkit distils some of these conversations, flags areas for critical engagement, and serves as a practical starting point for museum professionals who are interested in working with technologies that fit within the broad field of Artificial Intelligence. The aim of this toolkit is to support non specialists to better understand the possibilities of these technologies and empower a wide range of museum professionals to develop - strategically, ethically, and operationally robust project plans.

While developing this toolkit we have been approached by museums who would like support in understanding the possibilities of AI, clarification on key terms and an overview of the key things to consider when thinking about AI. This toolkit seeks to begin to answer those queries. It is designed to start a conversation. Conscious of the fast-moving nature of this field we decided against the inclusion of a definitive how to guide, but instead sought to provide space for critical reflection, we offer more questions than solutions. Since the toolkit was first published in 2020, we have worked with partners to develop German, Spanish and Italian editions, each of which has new case studies, and country specific contexts. We are now delighted to publish a new Chinese edition of the toolkit and to introduce innovative Chinese case studies to the wider Museums + AI community.

themuseumsai.network

Dr Oonagh Murphy

CHINESE CONTEXT

China has a long history and a profound cultural heritage. With the acceleration of global digital transformation, artificial intelligence has widely penetrated various fields of society and the economy. Chinese museums are also concerned about the impact of digital intelligence technology on museum exhibitions and management. Driven by policies and technological innovations, Chinese museums are actively exploring the application of AI and other digital intelligence technologies to cope with the wave of global digital transformation.

In the process of revising this toolkit, we interviewed several Chinese museums to hear their views on the introduction of AI in museums. One of them, Lin Shaoping, who is working for Xi'an Qujiang Museum Of Fine Art, said, "Whether for the museum industry as a whole or just for Xi'an Qujiang Museum Of Fine Art, when introducing AI, the first thing you need to do is to understand what specific roles AI can play in the work of the museum or for public services, and whether the technology is worth introducing. Secondly, it is important to consider safety, such as data security and safety of use. Thirdly, it is necessary to pay attention to whether the required investment can be proportional to the role, and what is the input-output ratio. In addition to this it is also important to consider aspects such as difficulty and ease of use and difficulty of maintenance. When working with external providers, it is especially important to consider data security." Another professional also shared with us that she believes it is important to have a thorough understanding of the functions of AI when introducing it. This facilitates better use of the technology by the museum staff and a better experience for the visitors. Also, museum professionals we spoke to mentioned the importance of data security when using AI. When seeking cooperation from outside, the cost of cooperation, such as the cost of hardware, software, systems, and the cost of manpower training should be taken into account.

It can be seen that AI technology is not yet mature and museums will need to take into account data security, ease of use, and cost of use when considering the use of AI technology.

We are delighted to share the work of the Museums +AI Network with museum professionals in China. We are excited to present two new case studies that exemplify how museums in China are engaging with AI technologies. We have produced the Chinese edition of the toolkit in both English and Chinese to support an open dialogue with museum professionals inside and outside of China.

Emma Louise Duester
Associate Professor
ICCI-Shanghai Jiao Tong University

THINKING ABOUT AI

When considering using AI technologies, museums need to think about the potential benefits and challenges such technologies present. This list frames some areas for consideration, however each museum exists within a unique context, and as such this list is intended as a jumping off point, from which to explore projects and partnerships with your wider team before a project has been fully costed, or funding sought for implementation:

Why AI?
The conversation around AI is often over simplified, with many technologies that fall within this conversation falling far short of having sentient intelligence, instead what we see is advanced algorithmic decision making. As such it is important to not only understand the technology you intend to use, but also what data it will require (as input) and what data it will generate as output. As with most 'new technologies' it can be appealing to engage with world leading companies, and become innovators of museum practice. However as previous trends from Apps to 3D printing have shown us, the best technology provides solutions to questions or challenges faced by a museum, rather than existing as an additional layer to a museums core mission. Technology used well helps to further your mission.

Just because it's legal doesn't mean it's ethical
Regulation in the UK and US around technology is somewhat lacking, and as such many technology solutions from facial recognition to algorithmic decision making are legal, but ethically questionable. Museums, as social purpose institutions must reflect upon their professional standards, alongside the law when it comes to developing and implementing AI technologies. Professional standards when it comes to digital practice in museums are perhaps best described as interdisciplinary with many of those working in digital departments coming from computing backgrounds, rather than museology. As such, engaging with a wide range of professional standards can help to inform nuanced practice that aligns to the mission and values of your museum.

Relevant codes of practice include:

- Museums Association - Code of Ethics for Museums (UK)
- American Alliance of Museums - Code of Ethics for Museums (US)
- Chartered Institute for Archaeologists - Professional Practice Paper: An Introduction to Professional Ethics (UK and International)
- International Council of Museums - Code of Ethics for Museums (International)
- Association for Computer Machinery - Code of Ethics and Professional Conduct (International)

Off the shelf tools
A number of AI tools can be used for free, or cheaply (often through a freemium model), these range from IBM Watson a natural language processing tool that allows you to analyse vast amounts of text based data, such as visitor feedback, quickly and cheaply. Or, machine vision tools such as Google Cloud Vision API, or Microsoft Azure which allow you to create metadata tags for images, something that can be useful when it comes to managing vast digitised collections. These 'off the shelf' tools are likely to become more sophisticated in the coming years, and as such more commonly used. However in order for museums to engage with such technologies in a manner that aligns with their mission, they need to be conscious of quality assurance and bias management.

Quality Assurance Process - Human Augmentation
When using any computational decision making tool it is important to have human quality assurance processes in place. Exploring what this process may look like, will help you to reflect upon the data created through AI tools, and how that data will be used internally, but also externally. Will the data be visitor facing? What are the implications of creating visitor facing data?

Bias management
Machines much like museums are inherently biased, as such whilst machine learning tools may provide valuable metadata for your online collection it could also create bias squared (museum bias x machine bias). As such understanding the training data used to teach the machine, and the algorithms used to make decisions are crucial to ensure the integrity of any application of these technologies within museums.

Brandwashing
Technology companies are keen to work with museums, particularly large museums with strong national and international brands. This can provide museums with access to cutting edge technology, custom built solutions (which can be much more effective than off the shelf tools), and support in kind from technology professionals. However, museums need to think about such partnerships in the same way that they do fundraising. What are the ethical implications of brand affiliation with a specific tech company? How does that relationship align with the mission of the museum? What are the potential unintended consequences of such a partnership?

Critical Technology Discourse
While some issues raised in this toolkit may sound problematic, these technologies are increasingly being used in wider society. Museums have an opportunity to critically engage with these technologies and the impact they have, by being open and accountable about what technologies they are using, and through public programs and contemporary collecting to develop visitor literacy around AI and Machine Learning Technologies. The Photographers Gallery in London has a strong critical technology discourse theme across much of its public programming, while the V&A has begun to collect AI technologies and associated art, such Anatomy of an AI System, by Kate Crawford and Vladan Joler (2018). The link between what happens in the digital team, public programs, and collecting could become more reflective and engaged through organisation wide transparency, dialogue and development.

CASE STUDY

The Palace Museum

The Palace Museum, founded on October 10, 1925, covers an area of more than 1 million square meters and is a large-scale comprehensive museum integrating ancient architectural complexes, palace collections, and culture and art through the ages, based on the Forbidden City, the imperial palace of the Ming and Qing dynasties, and its collections. The museum has a rich collection of cultural relics system is complete, the total number of existing collections of more than 1.86 million pieces (sets), the total collection of 25 major categories, covering painting, calligraphy, inscriptions, bronzes, gold and silver, and so on. In the past 10 years, the Palace Museum has stepped into the digital era, cooperating with Huawei, Tencent, and other high-tech enterprises to introduce advanced digital technology and equipment in the construction process of the museum. Currently, the Palace Museum has established a virtual "Digital Palace" and developed mobile apps such as "Daily Palace" and "The Emperor's Day" to enhance visitors' experience.

Establishment of CRM-ACA

As a world-renowned museum, the Palace Museum owns more than 1.86 million pieces of valuable collections, and in the face of such a huge collection, how to build a smarter management system is particularly important. The Ancient Chinese Artifacts Conceptual Reference Model (CRM-ACA) is a knowledge organization framework specifically for ancient Chinese movable cultural relics constructed by the Palace Museum. It is a solution designed to cope with the complexity of cultural relics' names, the low degree of information structuring and standardization, and the lack of effective relationship models between related concepts in the face of the challenges of constructing and sharing the knowledge organization system of museum collections in the era of big data. CRM-ACA aims to improve the machine-readability of the collection information and to create the conditions for the scaled use of the collection dataset for digital humanities research. The construction of the model is based on semantic network technology and knowledge mapping technology. CRM-ACA uses semantic network technology to transform the originally isolated and fragmented collection of information into a deeply related knowledge structure by constructing rich and standardized semantic relationships between concepts. This structured representation enables computers to go beyond simple keyword matching to understand the deeper meanings and associations of collection information. Based on the semantic network, CRM-ACA constructs a knowledge map, which is an intuitive and visual form of knowledge organization. The Knowledge Graph graphically presents all kinds of entities related to cultural relics, such as people, events, places, time, categories, etc., as well as the relationships between them, supporting multi-dimensional and multi-level cultural relics retrieval and knowledge exploration.

Developing a Digital Twin Intelligent Management Platform

On May 18, 2023, the joint innovation lab between the Palace Museum and Tencent Group was officially operated. Together with Tencent's Digital Twin team, the Palace Museum developed the Digital Twin Wisdom Management Platform, which integrates cutting-edge technologies such as digital twin technology, the Internet of Things (IoT), big data analytics, and Artificial Intelligence (AI), and is designed to provide comprehensive, accurate, and efficient protection, research, display, and education of the Palace's cultural relics. Today, AI technology plays a powerful role in cultural heritage protection, such as temperature and humidity control of exhibition halls, settlement monitoring of city walls, termite monitoring, ancient building disease monitoring, and audience flow monitoring. This management platform makes the management of the Palace Museum more intelligent. The management platform can control multiple systems in the laboratory, such as pipeline management, energy management, constant humidity management, intelligent storage, accesscontrol management,lighting management, environment management, etc. The Palace Museum deploys sophisticated environmental monitoring equipment to collect real-time temperature and humidity data in the exhibition hall. These data points are fed into the AI-based intelligent environment management system, which uses machine learning algorithms to analyze historical data, establish a temperature and humidity change model, predict possible future fluctuations, and automatically adjust the working status of air conditioners, humidifiers, dehumidifiers, and other equipment accordingly to ensure that the exhibition halls are always kept within the constant temperature and humidity required for cultural relics protection. In addition, the Forbidden City regularly uses drones to take high-altitude aerial photographs of ancient buildings, and the AI system uses deep learning algorithms to identify diseases on high-definition images, such as wood decay, masonry weathering, and color paintings falling off. Through regular comparison, the development process of the disease can be quantified, providing accurate data for the health assessment and maintenance plan of the ancient building. Real-time adjustments through the intelligent management platform can maximize the protection of cultural relics during the data collection process, ensuring accurate collection, efficient processing, permanent preservation, and flexible application of cultural relics data.

Potential challenges

Although the Palace Museum has built CRM-ACA and applied it to the " Digital Cultural Relics Library", with the growth in the number of collections, in-depth research, and the emergence of new technologies, it is a long-term challenge to continuously update and improve the knowledge graph to ensure that it accurately reflects the latest research results and related information of the collections. In addition, how to continuously follow up and integrate the latest IoT, big data, AI, and other technologies in the digital management platform to achieve more refined and intelligent conservation and management of cultural relics also requires continuous attention.

What can we learn from this case study?

The CRM-ACA constructed by the Palace Museum using semantic network technology and knowledge mapping technology effectively solves the structuring and standardization of cultural relics information, improves the machine readability and relevance of data, and lays the foundation for large-scale data utilization and digital humanities research. This shows that advanced knowledge organization and management tools should be actively introduced when dealing with complex and massive information. At the same time, it is necessary to focus on science and technology-enabled cultural heritage protection and realize all-round and refined monitoring and protection of cultural relics through cooperation with scientific and technological enterprises. By adhering to open cooperation and cross-border integration, and actively cooperating with high-tech enterprises we can realize the long-term goal of cultural heritage protection.

Artificial intelligence featured in this case study:

semantic network technology, knowledge mapping technology, machine learning

Useful links:

[1] Zhuang Ying, Artificial Intelligence-Oriented Knowledge Organisation of Museum Collections: An Example of the Conceptual Reference Model of Ancient Chinese Movable Cultural Relics in the Palace Museum

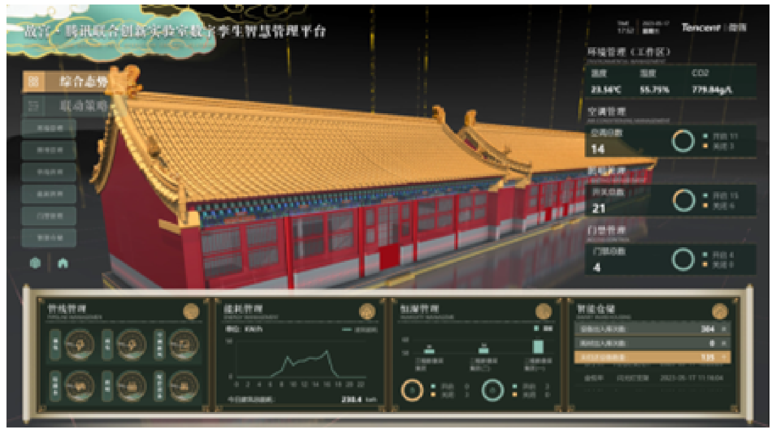
https://www.dpm.org.cn/journal/261970.html

[2] The Palace Museum

https://www.dpm.org.cn/about/about_view.html

[3] Digital twin technology helps to create a model room of the Forbidden City's intelligent cultural heritage

https://new.qq.com/rain/a/20230518A0686N00



Above: The Forbidden City Tencent Joint Innovation Laboratory Digital Twin Intelligent Management Platform

CASE STUDY

National Museum of China

The National Museum of China is located on the east side of Tiananmen Square in the center of Beijing, opposite the Great Hall of the People. The predecessor of the National Museum can be traced back to the establishment of the Preparatory Office of the National Museum of History in the first year of the Republic of China (1912), and the renovation and expansion of the National Museum of China was completed and officially opened to the public in 2012. The National Museum of China has a collection of more than 1.43 million items, covering ancient cultural relics, modern and contemporary cultural relics, works of art and other categories, with a complete collection system, a huge historical span, and a variety of materials and forms, involving oracle bones, bronzes, inscriptions and posters, glassware, silk fabrics, folk cultural relics, revolutionary cultural relics, etc. Early in 2018, the National Museum of China initiated the "Wisdom of the National Museum of China" construction project, making every effort to build a "Wisdom of the National Museum of China". At the beginning of 2018, the State Fair launched the "Smart State Fair" construction project to build a digital management and operation service system and to utilize the latest data network technology.

Digital intelligence empowers the museum service system

In 2022, the National Museum of China officially launched the first museum digital intelligent human, Ai Wenwen. Ai Wenwen is a joint project between the National Museum of China and Tencent. Tencent prefers to describe digital people as "Digital Intelligence Human", which they believe highlights their cultural connotations and the technology behind them more than digital human. Currently, Wenwen Ai mainly serves as a Chinese interpreter for exhibitions and artefacts. The development and training of the virtual digital intelligent human is highly dependent on Natural Language Processing (NLP) and multimodal human-computer interaction technology, which focuses on understanding and generating human language, allowing computers to parse, understand, and generate natural language text or speech. In the development of virtual digital intelligent human, NLP technology is the core to realize the ability of digital humans to "listen, read, and write", so that the technology can process the user's intention, answer questions, conduct conversations, and generate coherent and logical text or speech output. Through the speech recognition module of NLP technology, the digital intelligent human can convert the user's verbal inquiries or commands into text and understand its content, which is the first step of voice interaction with the user. NLP enables Ai Wenwen to accurately grasp the semantics, emotions, and intents of the user's words, including recognizing keywords, understanding contextual relationships, and parsing the structure of complex sentences, so as to make appropriate responses, and thus to provide the best response. The NLP-based dialog management system is responsible for maintaining the coherence and logic of the dialog, selecting appropriate dialog strategies based on user inputs, and invoking knowledge base information or performing specific tasks. As the virtual digital intelligent human of the National Museum, Ai Wenwen needs to have rich historical and cultural knowledge, and NLP technology helps the technology process and retrieve a large amount of cultural knowledge data, so that it can accurately provide the background of cultural relics, historical stories and other relevant information when users ask questions, and act as online and offline interpreters.

Above: The image of the digital intelligent human, Ai Wenwen

The core technology of multimodal human-computer interaction technology includes multimodal comprehension, multimodal generation, and multimodal fusion, which involves the exchange of information between the user and the computer system through a variety of perceptual channels. In the development of virtual digital humans, multimodal technology enables digital humans to receive and understand multidimensional inputs from users, such as speech, text, gestures, facial expressions, etc., and at the same time interact with users in a rich and natural way through various outputs, such as speech, images, animations, and haptic feedback.

Taking Ai Wenwen as an example, Ai Wenwen 's appearance design is based on the research of ancient costumes and the reference of cultural and creative products of the National Museum of China, and she creates a realistic virtual image through 3D modeling technology, and her movement and expression capturing technology ensures that her visual demeanor is highly reproducible with the characteristics of women in the Han Dynasty, which creates a   multi-dimensional visual communication. Ai Wenwen has speech synthesis capability, capable of generating natural and smooth voice responses to users' questions or commands, and lip movements are synchronized with the voice in real time, this audio-visual synchronized interaction enhances the realism of communication. Through multimodal technology, Ai Wenwen can recognize and understand the user's emotions and respond with appropriate expressions and tones to achieve emotional interaction and enhance the user experience.

Overall, multimodal human-computer interaction technology and NLP technology are closely related and deeply integrated in the process of developing virtual digital sages such as Ai Wenwen. The multimodal technology gives the digital humans rich sensory interfaces and three-dimensional interaction methods, while the NLP technology provides strong support for the core language interaction capability. Together, they build a highly anthropomorphic and intelligent communication experience for the virtual Digital Intelligence Man, enabling it to play an important role in museum education and cultural communication scenarios.

Potential challenges

The service process of the virtual digital intelligent human may involve a large amount of user interaction data, how to provide personalized services while strictly complying with the data protection regulations to ensure that the user's privacy is not infringed upon, will be an important issue that museums must face. In addition, there may be differences in the needs and expectations of audiences of different age groups and cultural backgrounds for digital intelligent human services. Museums need to deeply understand the user groups and continuously optimize the interaction design and content output of Digital Smarter to meet the needs of diversified visitors.

What can we learn from this case study?

Ai Wenwen rely on NLP technology to process massive cultural knowledge and disseminate it in a vivid and intuitive way, which breaks the limitations of traditional static displays and enhances the attractiveness and infectiousness of history and culture. As a new type of service carrier, the virtual digital intelligent human effectively expands the service boundaries of the museum and improves the service efficiency and quality. The virtual digital intelligent human can answer visitors' questions and provide personalized guides anytime, anywhere, enriching the visitors' experience, realizing the digital and intelligent transformation of the museum's service mode, and helping to enhance the public's cultural literacy and historical interest.

Useful links:

[1]The website of National Museum Of China

https://www.chnmuseum.cn

[2]National Museum Of China

https://baike.baidu.com/item/%E4%B8%AD%E5%9B%BD%E5%9B%BD%E5%AE%B6%E5%8D%9A%E7%89%A9%E9%A6%86/567902

Artificial intelligence featured in this case study: NLP, multimodal human-computer interaction technology

WORKSHEET

AI CAPABILITIES FRAMEWORK

An AI project requires resources and skills to gather, train and implement the data results. The goal of this worksheet is to discuss each of the following aspects of the capabilities needed to undertake this AI initiative.

Data

- What is the data that will be used for this AI initiative?
- How should the museum be prepared in terms of data infrastructure and governance?
- Is there an ethics committee in place at the museum to assess and oversee the compliance of this project?

Tools

- What are the AI methods and tools that would be employed?
- Would the museum use any external tools from technology companies?
- Are there open-source tools available for this AI project?

Resources

- What are the required resources? (Human, Financial, External Collaborations, Technological)
- What is the project legacy? What is the technical debt that needs to be considered?

Skills

- What are the skills museum staff need to work on this project?

Organization

- Which museum departments need to be involved?
- What is the ideal workflow and process to implement this AI initiative?
- Is the museum's organizational culture ready for this initiative?

Stakeholders

- What internal and external stakeholders would be invested in this project?
- How do you manage and communicate with the stakeholders?
- How do you foster early concept buy-in?

Project title	**Project aim**

Data	**Tools**

Resources	**Skills**

Organization	**Stakeholders**

WORKSHEET

AI ETHICS WORKFLOW

AI brings a set of ethical implications in each step of the initiative life cycle. The goal of this worksheet is to map the potential ethical issues and challenges that arise in each of the phases of an AI initiative from the data collection to the training, application and evaluation of the results.

Here are some questions to guide your discussions:

Data input: Collection & clean up

- What is the process to clean up the data?
- Has informed consent been gathered for this data?
- Is there any personal information?
- What are the museum processes to store and keep this data secure?
- Does the museum comply with the legal data privacy requirements?

Data output

- Can the process be documented and explained to users?
- What are the legacy and future applications of this data?

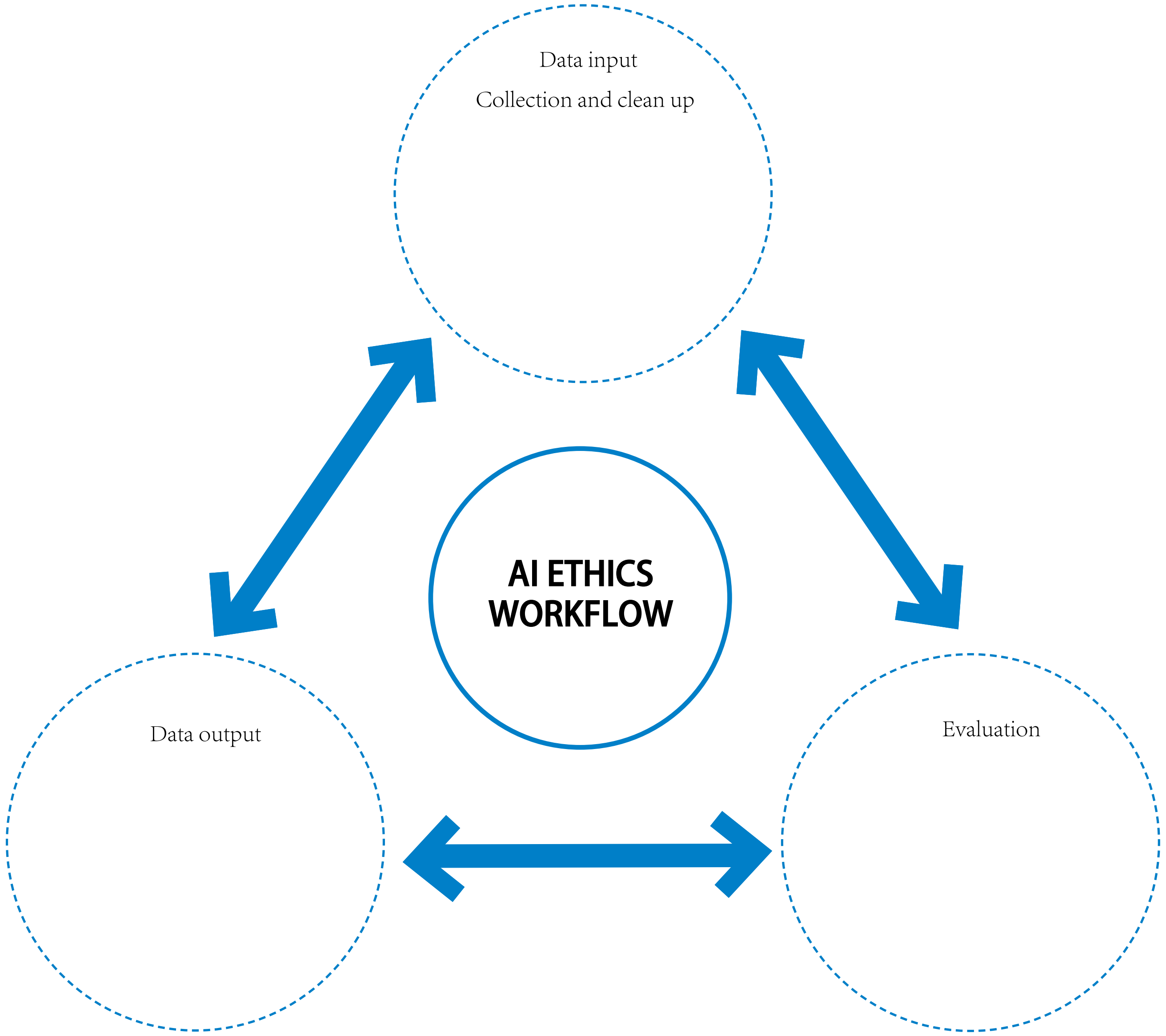
Evaluation

- How does the museum evaluate the success of this AI initiative?
- What is the impact on the visitor experience?
- How does this work enhance and expand the collection data?
- How do the results of this project comply with the code of ethics of the different museum associations?

The AI Ethics workflow presented here is an abridged version of the full AI Ethics Workflow developed by the Museums + AI Network.

Project title

Project goals



WORKSHEET

STAKEHOLDERS MANAGEMENT

AI projects involve many different partners, and it can be useful to map these partners or stakeholders at the project development stage. The goal of this worksheet is to think about everyone involved, interested and influential for your project. We suggest listing each person on an individual post-it note.

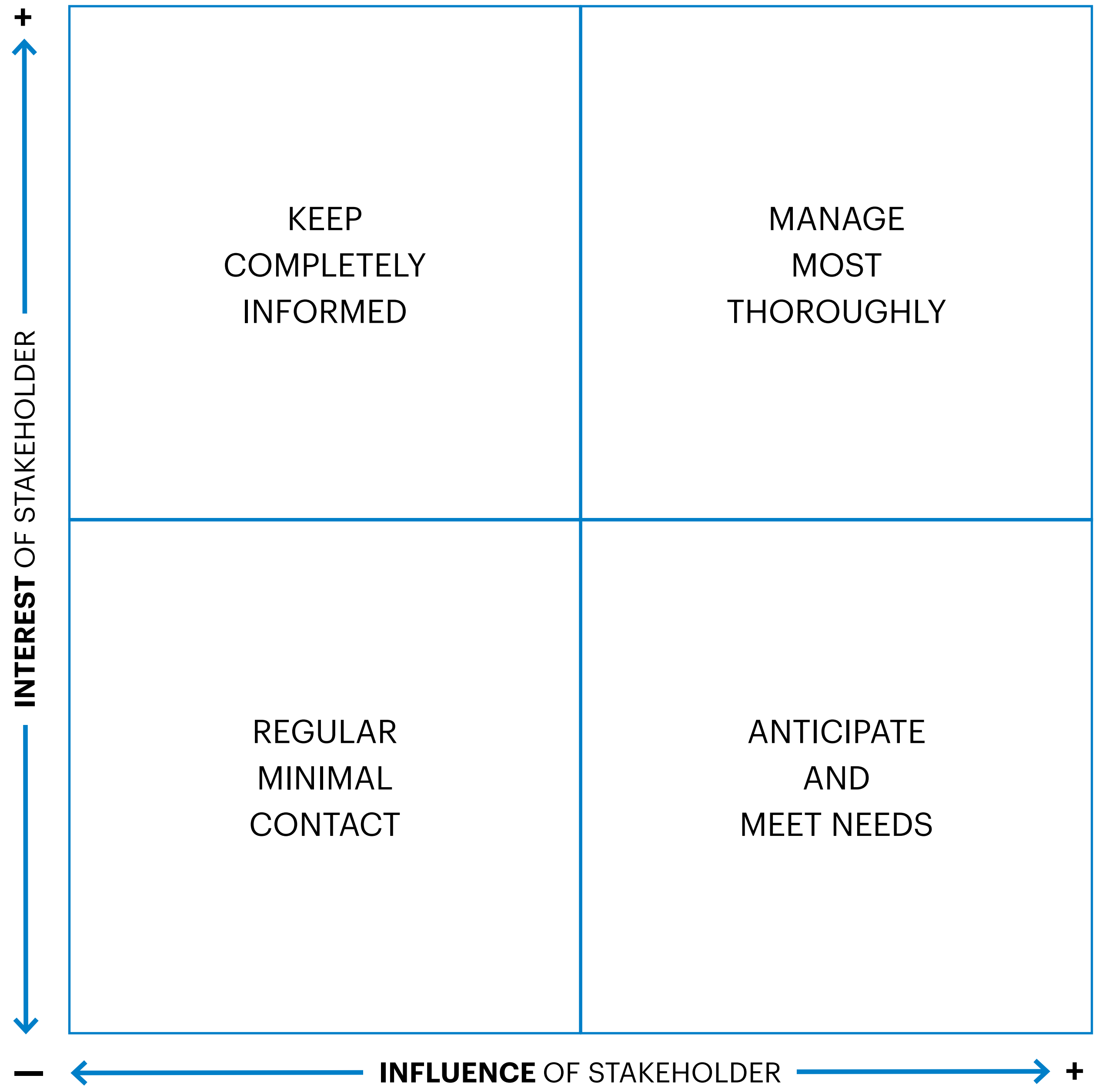
Criteria:

- Who will benefit from this AI initiative?
- Which internal stakeholders will need to support and contribute to the initiative in order to implement it?
- Are thereany specific areas of resistance within the museum?
- Who owns and manages the data that will be used?
- Who in the museum leadership would need to know about this AI initiative?
- Are there any external stakeholders that will participate in this project or where conflict of interest may appear?
- Who would you need to involve to ensure data privacy and ethical practices for this AI initiative?

When you have listed all stakeholders, as a group discuss where they sit within the stakeholder mapping grid, and from there think about when and how you will communicate with each stakeholder.

STAKEHOLDERS MAP: WHO NEEDS WHAT?

Project Title:



Adapted from Mendelow (1991)

GLOSSARY

Algorithm
An algorithm is a series of step by step instructions on how to perform a specific task. In computer science, different types of algorithms are used to recognise objects, translate between languages, recommend products and generate text. In many cases, multiple algorithms are combined to execute some of the more complex tasks. Algorithms are now being used in justice settings to determine prison sentences, and in financial contexts to create mortgage and insurance policies tailored to individuals based on their data footprint.

Algorithmic bias
Algorithmic bias refers to systematic errors in a computer system that create unfair outcomes, for example privileging one group of users over another. Bias can arise due to a number of factors, such as algorithm design, unintended applications or the way data is collected, coded, selected or used to train the algorithm. Impacts of algorithmic bias range from privacy violations to the amplification of social biases of gender, race, ethnicity and sexuality, which can lead to systematic and unfair discrimination in a wide variety of situations including prison sentencing, mortgage approval rates and healthcare premium calculations. In a museum context, algorithmic bias can manifest itself through inherent biases in museum collections, datasets and computer software applied to collection research and public engagement. An example of an art project highlighting bias in datasets is Kate Crawford and Trevor Paglen's ImageNet Roulette, which classifies a user's photo according to the popular ImageNet dataset. The resulting classification frequently gives unexpected and problematic results, particularly when used by people from Asia and Africa – groups which may have been underrepresented or labelled unfavourably in the original dataset.

Black box
A black box model is a system whose internal mechanisms are unknown.
In machine learning, "black box" refers to a model which cannot be understood from its parameters:
data goes in and decisions come out, however the process between input and output is unclear. This is particularly the case for neural network models, where input data can go through many transformations in the multiple layers of the neural network or where complex models can behave in unpredictable ways. The black box nature of many machine learning models is problematic because of their widespread application, giving rise to cases where individuals may be offered higher insurance premiums or denied mortgages based on the decision of the algorithm, which then cannot be explained. In the past couple of years, there have been increased efforts to develop more interpretable machine learning models, where the algorithms provide some justification or explanation for their decisions.

Chatbot
A chatbot is a computer program that is designed to mimic a human interaction in a text based conversation. These can be a useful tool for engaging with visitors on social media when a museum is closed, for example a Facebook Messenger Chatbot can answer simple questions about opening times, ticket prices and parking. Chatbots struggle with complex questions, and, for them to be effective a user needs to ask short, direct, factual questions. Chatbots can provide operational information - for example the Anne Frank House museum uses a chatbot to answer common visitor questions about visiting, but they can also be creative, for example the Field Museum created a chatbot with a sassy personality for the Maximo, their newly installed T-Rex exhibit.

Deep learning
Deep Learning is a subset of machine learning algorithms based on neural networks that use numerous layers, with each layer providing an interpretation of the data it feeds on. The multiple layers are used to progressively extract higher level features from the input data. To give an example from image processing, lower layers may be responsible for detecting edges, while higher layers determine concepts more understandable to a human such as faces, letters or digits. In recent years, deep learning has gained popularity given the huge amounts of data available online from social media, digitalisation efforts and online browsing as well as the availability of increased computation power through GPUs. An example application in a museum context is the use of deep neural networks for indexing the 800 million digital assets at the World Holocaust Remembrance Center in Jerusalem, with the aim of categorising its digital history for researchers and reaching a younger generation.

GAN (Generative Adversarial Networks)
A generative adversarial network consists of two neural networks: a generator and a discriminator. A generator creates images based on a dataset and a discriminator determines whether the generated image is real (i.e. it exists in the original dataset) or fake (i.e. generated). The interplay between the two networks enables the generator to create increasingly high-quality images that fool the discriminator. Most systems commonly used nowadays to generate images are a type of GAN. Examples of GAN-based projects includes Gen Studio, a collaboration between MIT, Microsoft and The Met. This project consists of images created using a GAN trained on artworks from The Met's Open Access collection.
The generated images enable you to explore and visualise possible artworks between selected pieces from the collections. For example, you can see what an object between a vase and a goblet could look like.

Machine Vision
Machine vision refers to technologies that extract insight from visual input such as images and videos. It looks at individual pixels and the features that are derived from them, seeking patterns in their variations. They include object and facial recognition.

These techniques can be used to find similarities between works across museum collections – examples range from Google's X Degrees of Separation, a project that links two objects through a series of other artworks, to Cooper Hewitt, Smithsonian Design Museum's website, where visitors can explore collections by colour, to Tate's IK Prize Winner 2016 Recognition, a project that matches contemporary photojournalism to art from the Tate's collection. Moreover, it could be used to analyse visitor responses to an exhibition by using facial recognition to analyse the gallery video feed.

Machine learning
Machine Learning refers to algorithms that learn to generalise from data, observations and interactions with the world, all without being explicitly programmed. This then allows the algorithms to make a prediction about something in the world, or to generate new, data based on what they have seen. Machine learning is frequently used as an umbrella term to describe a variety of algorithms including neural networks and deep learning. In a museum context, it is frequently applied together or as part of machine vision or natural language processing techniques. at National Norwegian Museum is an example of this. Here, machine learning technologies were applied to museum collections in order to give visitors easier access through better metadata and explorative interfaces. Generative machine learning technologies can be

used for interactive installations such as the Dali Lives project from the Dali Museum in Florida, where visitors are greeted by a deepfake (i.e. AI-generated lookalike) of Salvador Dali and can interact and engage with him on various screens throughout their visit.

Natural language processing
Natural language processing (NLP) deals with the interaction between computers and human (natural languages). The main objectives are to read, decipher, understand and generate human languages. Nowadays, most NLP techniques rely on machine learning. Applications of NLP include categorising content, analysing sentiments, translation, converting voice into written text and vice versa. In museum fields, NLP can be used to analyse posts from social media or ratings from tourist websites. An example is the inclusion of two virtual educators, Ada and Grace, at the Museum of Science in Boston, who answered visitor questions, suggested exhibits and explained the technology that made them work – including natural language processing.

Neural networks
Neural networks refer to a type of machine learning algorithm loosely inspired by how neural networks work in the human brain, particularly in terms of processing data and recognising patterns. Neural networks are made up of individual units connected via weights, which are then adjusted as the network is trained. The terms neural networks and deep learning are frequently used interchangeably nowadays, although there are some differences, the main one being the increased number of layers between input and output (hence the "deep"). Neural networks underpin a variety of applications in a museum context, such as being used to generate romantic landscapes in the National Norwegian Museum.

Predictive analytics
Predictive analytics is a branch of data analytics used to make predictions about unknown future events based on historical data. Predictive analytics uses a variety of techniques from data mining, modelling, statistics and machine learning to generate future insights based on data analysis. From a dataset of museum visitors, predictive analytics systems can estimate visitor numbers for an exhibition on a particular future date or assess the likelihood of membership renewal for certain customer groups. For example, National Museum of African American History and Culture used predictive analytics to research attrition, using data collected from e-tickets to predict demand and piloting Walk-Up Wednesdays to test no-pass entry.

Robots
Robots are machines that conduct mechanical, routine tasks automatically. Different types of robots are applied in industry, for grasping and moving objects in preparation for delivery for example. In a museum context, we normally deal with humanoid robots, which resemble human beings and are able to replicate certain functions and movements. Paris' Musée du quai Branly incorporated Berenson, a robotic art critic made to record people's reactions to artworks and then develop its own taste. The Smithsonian included the humanoid robot Pepper in the National Museum of African American History and Culture, where it is designed to deal with visitor queries and to tell stories using gesture, voice and an interactive touch screen. Meanwhile, the Van Abbemuseum offers a robot for anyone who cannot visit because of physical disability. These visitors can experience the museum from their own home by controlling the robot and guiding it through the museum themselves.

Supervised learning
Supervised learning is a type of machine learning that learns patterns entirely from a training dataset, where the data is labelled correctly with the right answer. Based on these patterns, it can predict answers in new data sets by reviewing them. For supervised learning, large labelled datasets are crucial to enable them to effectively generate output data. Incorrect or noisy data labels will reduce the effectiveness of the model. In a museum context, applications of supervised learning include predicting exhibition attendance or automating outreach for donors who may not be planning to renew.

Training Dataset
Datasets are one of the key pillars of machine learning. In supervised learning, a training dataset is a set of examples used to shape the model to ensure that it fits the data and is able to predict future outcomes correctly. The training dataset consists of pairs of input-output examples (e.g. a drawing of cat as input and a photograph of a cat as output), which teach the model how to map the inputs to correct outcomes. Given its importance in fitting a machine learning model, it is crucial to have training datasets which are as representative as possible for the future application of the model, as any incomplete or wrongly labelled data will be amplified further down the line as the trained model is applied on unseen data. To give an example in a museum context, if we are looking to make accurate predictions of cafeteria usage, we would need to make sure that the system is trained on multi-seasonal data. If cafeteria usage is highly seasonal and we only trained the system on the last two months, then it will only know about the current season and will provide less accurate predictions as the seasons change.

Unsupervised learning
Unsupervised learning is a type of machine/deep learning that finds structure where none is defined. It examines data and identifies patterns within it without guidance. It can be applied to find clusters of similar data, find anomalous data points that look different from everything else.
For example in a museum context, unsupervised learning could be used to analyse a dataset of museum visitors and identify clusters of weekends with high visitation (e.g. because of school holidays or certain exhibitions).

Sentiment Analysis
Sentiment analysis is the contextual mining of text which identifies, extracts, quantifies and studies subjective information and affective states in source material. It can be used to determine the overall attitude of a group – positive or negative – towards a product, organisation or topic. For example, this can help museums understand the social sentiment around an exhibition or artwork from online conversations on social media. The British Museum applied sentiment analysis to two years of TripAdvisor reviews to gain insights from visitor reviews on how visitors experienced the various aspects of a museum eg. exhibition, tours, facilities.

Object recognition
Object recognition is a general term to describe a set of computer vision techniques for identifying objects in images or videos. These techniques are used for deciding how to classify objects in an image, for identifying the locations of objects within an image or for both tasks. Object recognition includes a variety of possible applications in the museum field, from uses in research and collection management to identification of artworks and visitor engagement through interactive apps. An example of this is the Headhunt! App from the National Portrait Gallery in Australia, where kids can take pictures of the portrait artworks with an iPad and then access interactive learning experiences. Another example is Google Arts & Culture app Art Selfie, which asked users to take a selfie and then, using facial recognition, found the closest matching portrait artwork.

ACKNOWLEDGEMENTS

The content which this toolkit is based upon was developed through a series of workshops in London and New York that were held in summer 2019. We would like to thank workshop participants for their insights, critiques, curiosity and generosity.

Network Research Assistants

Dimitra Gkitsa, Goldsmiths, University of London

Seth Crider, School of Information, Pratt Institute

Core Network Members

Andrew Lih, Wikimedia Strategist, The Metropolitan Museum of Art

Ariana French, Director of Digital Technology, American Museum of Natural History

Carolyn Royston, Chief Experience Officer, Cooper Hewitt, Smithsonian Design Museum

Casey Scott-Songin, Senior Manager: Data & Insight, The National Gallery, London

Dan Brennan, Museum Application Developer, Princeton University Art Museum

Dr Juhee Park, Data Research Fellow, Victoria and Albert Museum Research Institute (VARI)

Dr Mia Ridge, Digital Curator for Western Heritage Collections, The British Library

Harrison Pim, Data Scientist, Wellcome Collection

Jamie Unwin, Collections Technical Architect, Science Museum Group

Jennie Choi, General Manager of Collection Information, The Metropolitan Museum of Art

John Stack, Digital Director, Science Museum Group

Lawrence Chiles, Head of Digital Services, The National Gallery, London

Rachel Ginsberg, Cooper Hewitt, Smithsonian Design Museum

London Participants

Ben Vickers, Chief Technology Officer, Serpentine Galleries

Dr Fiona Johnstone, Research Associate, Centre for Interdisciplinary Methodologies, Warwick University, People Like You

Dr Giles Bergel, Digital Humanities Research Fellow, Seebibyte, Faculty of Engineering, University of Oxford

Dr Sophie Frost, Research Assistant, One by One, University of Leicester

Hannah Barton, Digital Project Manager, Tate

Joe Padfield, Conservation Scientist, The National Gallery, London

John Davies, Economic Research Fellow, Creative Economy and Data Analytics, Nesta

Lisa Ollerhead, Head of Museums Policy, Department of Digital, Culture, Media & Sport

Meriel Royal, User Experience Researcher, The National Gallery, London

Natalie Kane, Curator of Digital Design, Victoria & Albert Museum

Nicolas Malevé, PhD Researcher, Centre for the Study of the Networked Image, London South Bank University

Philo Van Kemenade, Co-founder and Head Curator, Sensorium Festival

Professor Victoria Alexander, Institute for Creative and Cultural Entrepreneurship, Goldsmiths, University of London

Rachel Coldicutt, CEO, Doteveryone

Tom Cunningham, Data Analyst, The National Gallery, London

Tonya Nelson, Director of Arts Technology and Innovation, Arts Council England

Victoria Ivanova, PhD Researcher, Centre for the Study of the Networked Image, London South Bank University

Vishal Kumar, Futurecity Associate, Spatial Data Science and Visualisation, Centre for Advanced Spatial Analysis The Bartlett, University College London

New York Participants

Achim Koh, Visiting Assistant Professor, Pratt Institute

Adam Quinn, Digital Product Manager, Cooper Hewitt, Smithsonian Design Museum

Dr Anthony Cocciolo, Dean, School of Information, Pratt Institute

Dr Chris Sula, Associate Professor, Pratt Institute

Dr Craig MacDonald, Director, Center for Digital Experiences, Associate Professor, Pratt Institute

Effie Kapsalis, Senior Digital Programme Officer, American Women's History Initiative, Smithsonian Institute

Jeff Steward, Director of Digital Infrastructure and Emerging Technology, Harvard Art Museums

Kang-Ting Peng, Senior Engineer, Cooper Hewitt, Smithsonian Design Museum

Lawrence Swiader, Director of Digital Strategy, American Battlefield Trust

Matthew Cock, Chief Executive, Vocal Eyes

Shannon Darrough, Director, Digital Media, MoMA

Spencer Kiser, Lead Developer, The Metropolitan Museum of Art

Public event contributors

Andrea Lipps, Associate Curator of Contemporary Design, Cooper Hewitt, Smithsonian Design Museum

Dr Oliver Fletcher Vane, Living With Machines, British Library

Dr Sophie Frost, Executive Director, Furtherfield

Irini Papadimitriou, Creative Director, Future Everything

Karen Palmer, Storyteller from the Future

Laren Vargas, Research Assistant, One by One, University of Leicester

NOTES

Chinese Edition
Published November 2024
doi.org/10.25602/GOLD.00037891

Goldsmiths, University of London
New Cross
London SE14 6NW
gold.ac.uk