



TOWARDS
A NATIONAL
COLLECTION



Arts and
Humanities
Research Council

FINAL REPORT

FOUNDATION PROJECTS

DEEP DISCOVERIES

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The National Archives, UK | The University of Surrey |
Victoria & Albert Museum | Northumbria University |
Royal Botanic Garden Edinburgh | Museum of Domestic Design and Architecture |
Gainsborough Weaving Company | Sanderson Design Archive

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Executive Summary

Project Summary: Deep Discoveries was a Towards a National Collection Foundation Project exploring the application of computer vision (CV) and explainable artificial intelligence (XAI) methods for enhancing the ability of general audiences and specialist researchers to discover visual collections in new and/or more effective ways. The team developed and user-tested a CV-based search platform that allowed users to visually articulate their search task, understand how the CV algorithm found similarity between their input image and the returned image results, and to carry out a ‘visual dialogue’ with the AI to refine their search further. We aimed to design a platform that would allow users to both narrow-in on specific images during a directed search as well as to broaden-out and discover new collection items during an exploratory search.

Structure and Methodology: The project had three core participants: The National Archives (TNA), The University of Surrey (UoS), and The Victoria and Albert Museum (V&A); one consultant partner: Northumbria University (NU); and four project partners: The Royal Botanic Garden Edinburgh (RGBE), The Gainsborough Weaving Company, The Museum of Domestic Design and Architecture, and Sanderson Design Archive. The research was structured over two Work Packages. WP1, ‘Technology Development’, was led by UoS and involved the development of CV search and XAI algorithms for delivering new and/or more effective ways for cross-collection searching of digitised visual content. WP2, ‘User Assessment and Impact’, was led by TNA, V&A, and NU, and involved the assessment of visual collection users and their search/discovery habits and needs, in order to inform the design of a prototype search tool using the technology developed in WP1. A user research (UX) team, which included user experience researchers, a digital design specialist, and a software developer, was assembled from TNA and V&A. Experts in Interaction Design (ID) from NU assisted in the development of the search platform interface through a series of design sprints modelled on the agile method of working. The UX research team and ID experts worked iteratively with the UoS CV team in the research, development, and testing of the technologies and concepts. The developed search platform displayed images (ca 20,000) provided by all core participants and project partners. The search platform impact was assessed through a series of unmoderated and moderated user testing sessions.

Results: The UX research suggested that the CV search prototype should provide both discovery-driven and research-specific capabilities, and guide users to understand how these operate. The prototype should allow users to articulate their search criteria based on visual facets, though questions around user intent and training of the search algorithm would require the team to investigate the meaning of terms such as ‘motif’ or ‘style’ for different user groups. We instead chose to untether the technology from broadly defined notions of visual facets and create a platform that allows users to visualise how the AI determined similarity between their query image and the returned images. Thereafter, the users can select areas of interest on the result and query images in an iterative fashion in order to visually articulate their task and discover new content or hone-in on specific images.

We investigated several models for image feature extraction to do the visual search: three network architectures trained for semantic classification on ImageNet dataset; three style based models trained to discriminate fine-grained style collected from behance.net. We found that features extracted from all these models are suitable for our dataset. We adopted the GradCam method to explain the visual search results, which enabled us to present heatmaps to users that highlight image regions responsible for image matching. Next we introduced a patch-based retrieval approach for visual search. The key advantage of this approach is that users are able to take local feedback from the retrieved image (as a mask drawn using a brush-like tool) and the system can incorporate this feedback into the current search. This not only allows visual discovery within the image collection but also helps to disentangle the user's intention during visual search.

Unmoderated testing of the prototype showed that close to 85% of respondents agree that exploring using an image, rather than a keyword, would be useful when engaging with GLAM collections online, and all agreed that visual search would be a helpful tool. The majority of testers understood the XAI function of the prototype, including the ability to ‘see’ how the AI read similarity between the query and returned images (>85%), and the ability to modify their search criteria based on this information (>80%). The ability to select areas within the query and returned images was seen as ‘user-friendly’ and ‘useful’. Users found the process of searching with multiple images less intuitive, though most agreed it would be ‘useful’ (>30%) or ‘interesting’ (>55%). Several users noted that the selection feature on several images would create opportunities to discover new collections, and new *types* of collections, as well as to make connections across different cultures and time periods.

Moderated testing of the prototype revealed that users were interested in having an understanding of the scale of the image collections that they could search across, as well as the ability to aggregate, curate, and save their own ‘collections’ from different institutions in one place. Metadata and re-use permissions were key for all testers, as was the ability to navigate to the collection website from whence the images originated so as to gain more context and information. We found that testers in these sessions struggled to both understand and employ the XAI technology – all users found the heatmaps confounding though fascinating (what the AI finds similar is quite different to what our testers found similar between images). The ability to enter into a dialogue with the AI through modifying the returned images was also not picked up by the testers, though this may be attributed to the prototype design and novelty of the technology. Most of the testers intuited both the selection tool that allowed them to refine the search, as well as searching with several images simultaneously. The latter seemed natural to testers and allowed for creative deployment of the technology. Testers were interested in being able to refine by (1) negative filtering (e.g. ‘show *less* like this result’); (2) mixed visual and semantic search, for example by additional filtering based on media type, time-period, location, collecting institution, type of collection; (3) semantically articulated well-defined visual facets like ‘colour’.

Computer vision search was welcomed by all users as an exciting addition to their search and discovery tasks. Testers highlighted the potential of this technology for enabling search and discovery for users with certain disabilities like dyslexia, or for lowering access barriers for non-native English speakers and those users who lack technical language to describe their query. Users with prior experience of commercial computer vision search platforms highlighted that they (1) had more trust in the images and metadata returned in an institutionally-driven search platform, and (2) liked the lack of commercially-driven motivation in the returned results.

Outputs: Data from the project survey, unmoderated testing, as well as the background UX literature report can be found in the Annexes of this report. Examples of our user case studies as well as the methodology for developing the functionality of the platform are also described in the Annexes. A [long-form video](#) of the interface design process is available on YouTube. Recordings of the [project interim progress presentation](#), engagement event on [CV in Heritage Collections webinar](#), and [closing webinar](#) are all available on the Towards a National Collection YouTube channel. Our project’s interim report can be found on the [Towards a National Collection website](#). Our first [blog post](#) is available on The National Archives website and an interview for the [Europeana AI in relation to GLAM taskforce report](#) is available online. We presented our work the Archives in the UK/Republic of Ireland and AI (AURA) Network’s second workshop, to the Forum for Historic Manuscripts and Academic Engagement, at a TANC panel session for the DARIAH 2021 Annual Event on Interfaces, and have submitted a Case Study for the 2022 Human Computer Interaction conference. In January 2022, we will present the work to the Alan Turing Institute’s Computer Vision for Digital Heritage Special Interest Group. The [Deep Discoveries project webpage](#) and [GitHub page](#) will remain active for the duration of the Towards a National Collection research programme. GitHub also contains patched-based vision approach supporting the [backend](#) of the project and the [frontend code](#) supporting the live demo website. Two peer-reviewed manuscripts are planned for the project – one discussing the AI developments by the UoS team and one on the XAI and UX research carried out by all partners.

Abstract

The Deep Discoveries project explored the potential of computer vision (CV) search for content discovery within and between our nation's digitised image repositories. The research led to the design of a prototype search platform enabling cross-collection image linking by harnessing the ability of CV methods to identify and recognise visual patterns without the need for preliminary integrated descriptive metadata. Searching in this manner allows for content-linking based on attributes such as pattern, colour, and motif, and creates the opportunity for users to discover unforeseen connections between image collections across the country. The research also introduced explainable AI methods, which allow users to enter into a visual dialogue with the AI so as to refine their search tasks. During the 18-month project, research carried out by a user experience research (UXR) team from two GLAM Independent Research Organisations (The National Archives and the V&A Museum) informed the work of computer vision scientists at the University of Surrey. Using an agile working methodology and design sprints, the technological advances and UXR findings were integrated into a prototype design by consulting Interaction Design (ID) partners from Northumbria University. The Deep Discoveries project worked with four partner organisations representing different owners and creators of visual collections to open up participation in funded research to smaller organisations, to glean a better understanding of their needs, and to assess the opportunities and challenges involved in gathering visual collections for the purpose of employing CV-based search and discovery tools.

Aims and Objectives

The Deep Discoveries Foundation Project had three objectives, which were interdependent and of equal priority and two objectives that are specific to the Towards a National Collection: Opening UK Heritage to the World Strategic Priorities Fund Programme:

1. Develop a CV-search software platform for matching content within and across collections, enabling visual records to be linked based on properties such as pattern, style, colour and other visual motifs.
2. Develop methodologies to survey how, or if, current users of digital image collections in the UK employ visual search, evaluate the real and perceived barriers to user access and discovery of collections using CV search, and propose methods that can be used to evaluate the success of the proposed technological advancement.
3. Convene workshops, interviews and surveys, and carry out a literature review to explore current methods for engaging, evaluating, and diversifying audience access to online visual collections; scope the ethical issues of deploying AI to image searching in digitised collections; and showcase proof-of-concept technology.
4. Through dissemination and engagement activities, encourage the integration of computer vision search technologies in Discovery phase projects.
5. Produce this report on the findings from the research, which can be used to provide evidence-based recommendations on next steps in the field.

The project was structured around two work packages (WPs). WP1 involved technology development and deployment, while WP2 revolved around user assessment, development of methods to engage new audiences, ethical questions, and technology uptake and impact assessment.

Partnership Structure

Core Participants:

The National Archives, UK (TNA): The Principal Investigator (PI), Co-Investigator (CI3), Project Administrator (PA), UX Research Staff (RS2) and Software/User Interface Developer (RS3) were based at TNA's Collection Care, Research, and Digital Services departments. The team led on WP2 – user-centric research, as well as coordinating the project, and ensuring delivery. The organisation supplied 7,845 images from the Board of Trade Registered Designs collections. The collection has jpeg images with unique image IDs; other forms of metadata were not available. The images were primarily of textile design patterns, many, though not all, featuring a botanical theme.

University of Surrey (UoS): CI1 and Post-Doctoral Research Associate (RS1) were based at UoS Centre for Vision, Speech and Signal Processing (CVSSP); the team led on WP1 – technology development – by ingesting and keeping secure images provided by all partners, exploring existing and developing new CV algorithms for the project, and working closely with the UX research and Interface Design teams to develop the search prototype.

Victoria and Albert Museum (V&A): CI2 and UX RS4 were based at V&A's research institute (VARI) and Digital Media department; the team worked on WP2 with RS2 completing the UX research team. The organisation supplied 426 images from their collections. The images primarily featured floral patterns and designs on paper, though not all featured a botanical theme. Other forms of metadata were not available for this collection.

Northumbria University School of Design (NU): Experts in Interaction Design joined the project as consultants to assist UoS, TNA, and V&A in the development of the search platform interface through a series of design sprints modelled on the agile method of working.

Project Partners: Partners on the project attended project meetings, participated in workshops and surveys and contributed valuable information around the use and state of their digitised visual collections.

Royal Botanic Garden, Edinburgh (RBGE): The organisation supplied 7,435 images and associated metadata such as scientific names, photographer, collector name and number, and catalogue number and licence links. The images were primarily botanically themed including leaf and flower sketches, photographs of leaves, mountains, bushes, flower/seed/fruit of plants. Two staff members assisted the project.

Museum of Domestic Design and Architecture (MoDA): Part of the Middlesex University, MoDA's collections feature designs for wallpapers and textiles, many of which have a floral or botanical theme. Two staff members contributed time in-kind worth £3,000 to the project, as well as 1,170 digitised images and the associated metadata. The annotations contained i) short description of image content (e.g. Design for a textile of red, blue and yellow flowers); ii) materials/technique used (e.g. Watercolour on detail paper) and iii) production date.

Gainsborough Weaving Company (GWS): The archive of the weaving studio features thousands of images of historic textile designs, as well as contemporary designs added as they are produced; however, few have been digitised thus far. One staff member offered time in-kind worth £600, as well as 760 images to the project.

Sanderson Design Archive (SDA): The archive's collections feature hand-painted, flower-group designs and floral-patterned textiles and wallpapers. One staff member offered time in-kind worth £1,645 as well as approximately 950 images and the associated metadata which include i) image-type (Wallpaper/Textile/Handprinted-Wallpaper); and Collection name (e.g. Triad 1968-69 3rd Edition, riad 1970-71 Collection)

Staffing Structure

PI: Lora Angelova, Head of Conservation Research and Audience Development, TNA: project direction, reports, liaising with Programme Director and Foundation Projects; ensured delivery of project to proposed timeline and budget

CI1: John Collomosse, Professor of Computer Vision, UoS CVSSP: direction and lead on visual search development; supervised PDRA RS1, contributed to final report

CI2: Joanna Norman, Director of the V&A Research Institute, V&A: V&A data access; provided collection-specific advice

CI3: Pip Willcox, Head of Research, TNA: facilitated links with partnership networks

RS1, PDRA: Dipu Manandhar, Research Fellow, UoS CVSSP: development of visual search technology, worked closely with UXR and ID teams

RS2: Hari Chandrapal and Jenifer Klepfer, UX Researchers, TNA: part of UXR team, led on UX methodologies and user interviews, insight from TNA UXR expertise

RS3: Bernard Ogden, Research Software Engineer, TNA: part of UXR team, led on UX methodologies and frontend software development

RS4: Jack Craig, Design Lead, V&A: part of UXR team, led on UX methodologies, advising on search and discovery for V&A collection website and the challenges in enabling discovery with a large heterogeneous dataset

Consultants: Jo Briggs, Jamie Steane, Andy Cain, University of Northumbria School of Design: led on prototype design and supported UXR team, led on unmoderated testing and dissemination activities

Project Administrator: Rachel Smillie, Head of Academic Partnerships, TNA: worked closely with PI to aid in project delivery – scheduling meetings, sending out information and reminders, organising workshops, managing project budget

Revised Overall Programme

Figure 1: Gantt chart illustrating project timeline; 'break' in dating illustrated with red line demonstrates COVID-19 delay. Timeline has been updated since interim reporting. Deliverables named in Table 2.

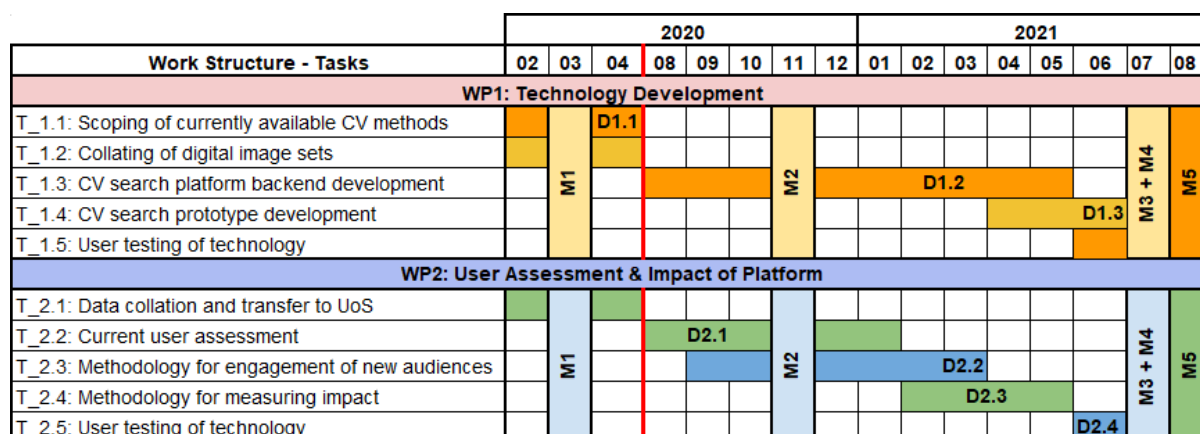


Table 1: Responsibilities of core project participants and project milestones

DELIVERABLE		LEAD*
WORK PACKAGE 1		
D1.1	Evaluation of currently available CV technologies	UoS
D1.3	Backend development based on UX research (D_2.2)	UoS
D1.4	Frontend prototype development	TNA/NU
D1.5	Final project report	TNA/all
WORK PACKAGE 2		
D2.1	Methodology to evaluate current user access	TNA/V&A
D2.2	Methodology to reach more audiences, addressing ethics questions	TNA/V&A
D2.3	Prototype interface development	NU
D2.4	User evaluation of technology	TNA/V&A/NU
D2.5	Final project report	TNA/all
MILESTONES		
M1	Project kick-off meeting (internal)	
M2	Workshop 1 + Project meeting 2	
M3	Technology developed to user-testing stages	
M4	Closing webinar + Project Meeting 3	
M5	Final report	

* TNA - The National Archives, UoS - University of Surrey, V&A - Victoria and Albert Museum, NU – Northumbria University

Events and Consultations

	EVENT/CONSULTATION	DATE(S)	ATTENDEES/ RESPONDENTS
M2	Workshop 1 (virtual): ‘Understanding current and potential users’ goals and behaviours when working with Visual Collections online’	28.09.2020	11 + 7 DD facilitators
D2.1	Interviews with Visual Collection Specialists	08-10.2020	5
D2.2	Open survey based on Workshop 1 input	01-03.2021	243
-	Interim Project update webinar	22.02.2021	104
-	Engagement event - CV in Heritage Collections webinar	30.04.2021	80
D2.4	Unmoderated static prototype testing using Maze	06-07.2021	24
D2.4	Moderated live prototype testing (interviews)	06-07.2021	6
M4	Closing webinar	21.07.2021	100

Talks/Posters/Interviews

13.05.2020: Blog post ‘Deep Discoveries: A new way of exploring and connecting digitised image collections’ by Lora Angelova and Liz Fulton published on The National Archives website

09.2020: Interview of Bernard Ogden by Aberystwyth University Archive Administration MA student Chiara Fallone about different ways archival institutions are using emerging technologies

04.11.2020: Poster presentation about the project at The National Archives' Annual Digital Lecture by Carly Kind, 'The death of anonymity in the age of identity'. A follow-up Twitter chat around the posters was held on 09.11.2020

25.11.2020: Interview of Lora Angelova with input from John Collomosse and Dipu Manandhar by Giles Bergel for Europeana's AI in GLAMs interim report

28.01.2021: Invited talk and workshop participation of Bernard Ogden and Lora Angelova at the Archives in the UK/Republic of Ireland and AI (AURA) Network's second workshop

17.06.2021: Presentation to the Forum for Historic Manuscripts and Academic Engagement by Lora Angelova and Bernard Ogden

07.09.2021: Panel presentation by Bernard Ogden and Jo Briggs at DARIAH Annual event, 'The Interface(s) of a Virtual National Collection'

27.10.2021: Interview-style blog by Lora Angelova and Bernard Ogden associated with The National Archives' Annual Digital Lecture

07.01.2022: Presentation/workshop with John Collomosse, Dipu Manandhar, Lora Angelova for the Alan Turing Institute Computer Vision for Digital Heritage Special Interest Group

Research Approach

User Research Approach: The UXR team carried out a desk research exercise to inform the design of a prototype visual search system, particularly with respect to potential use cases and interfaces. Semi-structured interviews with people working in various fields of design were carried out alongside a virtual workshop that gathered collection engagement experts from the project partners and networks. The findings from these scoping exercises informed the design of an online survey that asked respondents to reflect on their experience when using reverse image search engines. Questions on the benefits and challenges of computer vision-based searching helped the team to refine a set of ideas to guide the development of the project prototype. Through the creation of three use cases, the UXR team developed a prototype wireframe, which served as a catalyst for technology development with the UoS team.

The literature review, interviews, and survey responses also highlighted several problematic or exclusionary aspects of CV search. Although our proposal raised questions such as 'What are the ethical implications of applying visual search to heritage collections?' and 'How can we avoid perpetuating bias and colonial practices in the virtual realm, how can we engage more diverse audiences with our collections?', it became apparent that the depth and complexity of these issues were prohibitive in the context of this short project. Instead, we focused on the development of algorithms that would allow for a dialogue with the AI that leads to refinement of the results to suit the diversity of users and tasks. A future aim to develop algorithms that are re-trained on the fly, based on the users' refinement activities has also been proposed.

Once the CV search aims had been established, the UXR team worked with the ID and UoS teams to agree on an appropriate proof-of-concept user interface. Following the frontend development, the UXR team created a moderated testing scenario and semi-structured interview questions for usability testing. Respondents from the earlier survey who had expressed a desire to participate in usability testing were invited for interviews. We selected users who had, and had not, previously used CV search. Six interviews¹ were carried out using the live prototype; the sessions were recorded and notes

¹ Studies have shown that no more than 5 users are necessary for understanding usability and ensuring a maximum cost/benefit ratio. Nielsen, Jakob, and Landauer, Thomas K.: "A mathematical model of the finding of usability problems," Proceedings of ACM INTERCHI'93 Conference (Amsterdam, The Netherlands, 24-29 April 1993), pp. 206-213.

were captured by an observer during each session. Feedback from the interviews was analysed by the UXR and ID teams, and results shared across the project network.

Computer Vision Research Approach: The web live prototype designed by the ID and UXR teams serves as the user interface to access the backend of our search engine. Once a user submits a query image to the search engine, the image is processed through the backend machine learning algorithm. This process involves visual feature extraction from the query image carried out using a convolutional neural network (CNN). The UoS team assessed seven CNN models for the search engine; three visual style models trained to discriminate fine-grained visual styles on approximately 1 million images (external to the project) from behance.net (ALADIN-S,² ALADIN-L,³ AVit³), three semantic models trained on the ImageNet dataset using contrastive learning to classify 1,000 object categories (RESNET,⁴ VGG-16,⁵ ViT⁶), and a fused (hybrid) model of any of the above visual and semantic models.

A triplet network architecture with three CNNs which share the network weights was used for training. During training, the network is presented with an image triplet: an anchor (reference) image, a positive (visually similar to the anchor) image, and a negative (visually dissimilar to the anchor) image. The training process aims to bring the positive image closer to the anchor image in an abstract feature embedding space, while pushing the negative image further from the anchor image. Once trained, this feature embedding space is used for image retrieval; e.g. during a visual search with a query image, the system maps the extracted visual features of the new image against the visual features from all images in the database in the embedding space and is able to locate images that are visually speaking 'nearest neighbours' to the query image. These are returned to the user as results ranked by relevance.

Based on feedback from users in the first phase of UXR, we found that (1) heritage collections online are searched by many different users with a variety of tasks, (2) users were interested in understanding which visual features in the results images the AI found similar to their query image, and that (3) they would like to search on specific visual facets within their query images. As a result, we modified our approach by adapting the Grad-CAM technology⁷ – used for visually demonstrating how a CNN is functioning – for our computer vision search engine. Grad-CAM was initially proposed for explaining the image classification networks. We adopted Grad-CAM for triplets of images that allows visualizing the image similarity and produces heatmaps on retrieved images that highlights the regions responsible for similarity. The heatmaps are overlaid on the top ranked returned images that codes areas deemed visually similar or dissimilar in red or blue, respectively.

In order to allow user interactive visual search and introduce visual discovery ability, we moved away from holistic, or global, analysis of the image by CNN to a local level visual analysis. Specifically, we employed an 5x5 grid system that divides the image into patches prior to feature extraction. This 'patchification' of the image allows us to use the Bag of Visual Words (BoVW) model, which breaks down the image into local representations called 'visual codewords'. The visual codebook is built using clustering local patch features using the K-means algorithm. The codewords form a 'codebook' (visual vocabulary) that is then used to create a histogram of the image where each codeword is weighted based on its frequency in the image. Each image will have a different codeword histogram; these are cast, as before, in a feature embedding space where their distance relative to other image histograms

² Ruta, Dan, et al. 'Aladin: All layer adaptive instance normalization for fine-grained style similarity'. Proc. International Conference on Computer Vision (ICCV 2021). arXiv preprint, arXiv:2103.09776 2021

³ Ruta, Dan, et al. StyleBabel: Fine-grained visual style tagging and captioning dataset' Under review

⁴ He, Kaiming, et al. Deep residual learning for image recognition, in CVPR 2016

⁵ Simonyan, Karen and Andrew Zisserman 'Very deep convolutional networks for large-scale image recognition' arXiv preprint, arXiv:1409.1556 2014

⁶ Dosovitskiy, Alexey, et al. 'an image is worth 16x16 words: transformers for image recognition at scale' arXiv preprint arXiv:2010.11929 2020

⁷ Grad-CAM: visual explanations for deep networks via gradient-based localization, R. Selvaraju, M. Cogswell, A. Das, R. Vedantam, D. Parikh, and D. Batra. ICCV , page 618-626. IEEE Computer Society, (2017)

will determine whether they are considered visually similar or dissimilar. Patchifying the query image thus allows us to match parts of the image to parts of the returned images. The addition of the technology developed allows users to (1) search with a whole query image or to select specific parts (facets) of the image to search on, (2) see how the algorithm assessed similarity between the top ranked returned images and the query image, (3) select multiple returned images to carry out further visual search using either the entire images or annotated areas therein,⁸ (4) continuously iterate this process to hone in or expand their search and discovery of the collection. The technology creates a dialogue with the AI, allowing for iterative searching with live user feedback. As such, we are aiming to visually disentangle the user's intention (particularly useful if the user does not know how to articulate attributes in the image) and to provide a personalised search experience.

User Interface Research Approach: To support the design and development of the search prototype, Interaction Design (ID) experts from NU joined the project early in 2021. Their design process was focused on two tasks: (1) enabling the deployment of a radically novel computer vision search process while (2) designing pragmatically for the creation of a functional prototype. Because the backend was still under development at this stage in the project, the ID team worked 'blindly' and in parallel with the technology evolution. To deliver a prototype that could disrupt and challenge pre-existing search tropes and anchor the UXR and UoS team's ideas into a concrete object, the ID team proposed the cross-cutting theme of explainable AI (XAI). The Agile method was employed during the design research process, with four Sprints each lasting 2 weeks and ending with an all team meeting:

- Sprint 1: User experience design including the creation of UX epics (Annex 4)
- Sprint 2: User interface design including the creation of prototype wireframes to demonstrate the structure, layout, and options for the organisation and display of very large amounts of visual information.
- Sprint 3: Prototype interface design delivery 1
- Sprint 4: Prototype interface design delivery 2 or further exploratory design work

The ID team continued to regularly meet with the software developer and UXR team until the live prototype had been completed. In tandem, a static prototype was created for unmoderated remote user testing and feedback using the [maze.co](https://mazes.co) platform. Results from this testing exercise were summarised and shared across the project network.

Front end development: At the conclusion of the final user interface research sprint, the ID team produced a list of requirements using the MoSCoW method (Annex 5). This divides requirements into 'Must have', 'Should have', 'Could have' and 'Won't have', which largely determined the order in which features were added. The front end was implemented mainly in React and Material-UI, with most functionality implemented with off-the-shelf components from these toolkits or other open source libraries. The annotation tool was reworked from an open source avatar selection tool. The combination of web and open source technologies made it possible to produce a great deal of interface functionality very quickly. The team were occasionally invited to comment on the live prototype during development and it continued to provide a concrete object to focus discussion about the right way forward for the interface. Integration with the backend also had consequences for the design of the whole system, for example raising a question as to whether the original search image should have special weight in the system. Creating a live system, as with creating wireframes and static prototypes, was thus a part of joining up the various strands of research and of focusing attention on details. That said, the live prototype is just one possible realisation of our research. Further iterations could explore the consequences of different design decisions or could be used to explore particular aspects of the research questions.

⁸ 'Annotation' is used throughout this report to designate the ability of the user to select/highlight areas on the image using a brush-like tool.

Research Results

Desk and Preliminary User Research

A detailed report based on the outcomes of the interviews, first project workshop, and literature review can be found in Annex 1. The evidence gathered through the literature review confirmed expected differences between institutions and/or collections in both online audience makeup and the uses that audiences are making of the collections. Many users are engaged in specific search tasks to reach a desired goal; ‘just browsing’ is a less common task. Users have built-in expectations of digital heritage collections systems that are shaped by popular digital platforms, but different kinds of audiences will have varied expectations for the platforms and interfaces, and might want to engage with collections content in a variety of ways while seeking to accomplish myriads of tasks.

Initial surveying suggests, as has been highlighted by others, that vast amounts of the collections we would like to visually search across are either not digitised, or are only now beginning to be digitised. The format and quality of available images varies from organisation to organisation, and metadata type (if at all available) is also varied. There is a tension in presenting online visual collections between giving the user an understanding of the full scale of a collection (this can be overwhelming, and also misleading as most organisations have digitised only a small fraction of their entire content), and supporting exploration through guided recommendations, which can trap users in a filter bubble.

In interviews with users working in the general field of ‘design’, we found that Google Image search (e.g. searching for images by keyword, rather than visual search) was the most frequently used method for visual discovery. Only one participant had used Google Reverse Image (a visual search), generally when looking for the origins of an image (the story behind it, who owned it, what era it was from), and to understand the original elements within the image, such as colour, texture and materiality. With the exception of colour, facets⁹ presented within the wireframe to interviewees, meant different things to different participants. This finding was echoed during our workshop, as collection specialists used terms like motif or style in subject-specific ways.

The survey (data in Annex 2), which also featured responses predominantly from users engaged in art and design, confirmed that although users were aware of, and had employed reverse image search tools online, they did so only ‘sometimes’ or ‘rarely’ (80%). The majority of respondents used visual search to find identical or similar images to their query image, and to then derive further information (e.g. creator, date of creation, re-use and copyright status). This task was also frequently used in the context of tracing plagiarism and copyright abuses of their own (or their organisations’) images. Survey respondents noted creative uses of the technology, including ‘unexpected results’, ‘flexibility’ and ‘efficiency’ when the only search criteria available is an image or visual theme, and freedom from needing to articulate visual ideas and concepts. However, many noted that the technology was seen as novel with poor standards and functionality that required further development. Results were often unexpected or irrelevant, some platforms were not user friendly or ‘overwhelming’, filtering or faceted searching was not an option, and trustworthy metadata was rarely available.

The findings from this phase of the research suggested that the prototype under development should be able to provide different kinds of search options (e.g. both discovery-driven and research-specific), as well as function in a way that guides non-expert audiences or researchers to understand how these different types of searching operate. The prototype should allow users to articulate their search criteria based on visual facets, though questions around user intent and training of the search

⁹ By ‘facets’ we mean single dimensions of a multi-dimensional search. In the context of visual search, facets might include quite concrete visual characteristics such as “colour” or “brightness”, through more abstract characteristics such as “depth of field”, to abstract concepts such as “theme”.

algorithm would require the team to investigate the meaning of terms such as motif or style for different user groups. To establish whether different types of users' definitions of these terms during CNN training result in significantly different sets of returned images would have required a separate strand of research that was not accomplishable within the scope of our project. At the interim project meeting, these complications were discussed alongside wireframe sketch-ups of a proposed prototype based on one of three Case Study problem statements derived from the UX research (Annex 3). A decision was made to untether the technology from broadly defined notions of visual facets and create a platform that allows users to visualise how the AI determined similarity between their query image and the returned images. Thereafter, the users can annotate both the result and query images in an iterative fashion in order to visually articulate their task and discover new content or hone-in on specific images.

Computer Vision Algorithm Development

The ability for the CV AI to 'explain itself' through the returned images allows users to refine the way that the technology carries out a search and to disentangle and visually articulate the user's intention. This process presented (1) a challenging research question for the technology development in generating a novel CV algorithm and refinement process that has not previously been demonstrated for visual searching, and (2) an option to bypass the need to create strict definitions of ambiguous terms like style or motif, which have different meanings to different users, and during different tasks.

We investigated several models for image feature extraction to do the visual search. Specifically, we employed three network architectures trained for semantic classification on ImageNet dataset; three style based models trained to discriminate fine-grained style collected from behance.net. We found that features extracted from all these model suits for our dataset composed of images from various national collections. We further adopted the GradCam method to explain the visual search results. We demonstrated that GradCam can be used for image similarity based on triplets. This enabled us to present heatmaps to users that highlight image regions responsible for image matching. Next we introduced a patch-based retrieval approach for visual search which is demonstrated to work well for our problem. The key advantage of this approach is that users are able to take local feedback from the retrieved image (as a mask drawn using a brush-like tool) and the system can incorporate this feedback into the current search. This not only allows visual discovery within the image collection but also helps to disentangle the user's intention during visual search. All of the above features were successfully implemented into the live prototype.

Technology deployment – Interface Development and Testing

The final prototype interface design¹⁰ was agreed by all teams; the live prototype¹¹ was launched in June 2021 and will be available for six months after the project end date – through January 2022. Results from the unmoderated testing were largely positive, though some users failed to complete all tasks. This was attributed to misunderstanding that the unmoderated testing was based on a static prototype and with pre-programmed options and results (i.e. the user could not upload their own image or select areas outside the predetermined ones). Close to 85% of respondents agreed that exploring using an image, rather than a keyword, would be useful when engaging GLAM collections online, and all agreed that visual search would be a helpful tool. The majority of testers also understood the XAI function of the prototype, including the ability to 'see' how the AI read similarity between the query and returned images (>85%), and the ability to modify their search criteria based on this information (>80%). The ability to select areas within the query and returned images for further

¹⁰ A video walk-through of the process and prototype design can be seen online https://youtu.be/gEuU_zf223g accessed 02/09/2021

¹¹ <https://tanc-ahrc.github.io/deep-discoveries-frontend/> accessed 02/09/2021

refinement of the search was seen as ‘user-friendly’ (in the sense that subject-specific terminology was unnecessary) and ‘useful’. Users were excited about the potential of the technology if deployed across collections:

This is an exciting and interesting technology that will completely change the way in which I will be able to interact with visual collections. I can't wait for it to be applied to larger data sets. Not only is it useful for research, but the interface is just fun and entertaining. It makes you want to just play with it for a long time. I can imagine that this is even more the case when that are more images in the system.

In contrast to the moderated usability testing, users found the process of searching with multiple images less intuitive, though most agreed it would be ‘useful’ (>30%) or ‘interesting’ (>55%). Several users noted that the annotation feature on several images would create opportunities to discover new collections, and new *types* of collections, as well as to make connections across different cultures and time periods. The technology was viewed as an enabler for both discovery-driven and research-specific search tasks.

The moderated testing took place through the live prototype, allowing users to explore the functionality of the technology more freely, as well as to carry out a predetermined search task. We encouraged users to ‘think out loud’ as they explored the platform and recorded their feedback. Although the interviews were focused on usability of the prototype, we could gather some information around the testers’ interpretation of, and opinions on the technological developments. Unfortunately, due to the short timeline of the project, it was not possible to fully disentangle whether any complications were caused by prototype functionality or by the ability of users to immediately grasp and deploy a completely new type of search technology. Traditionally, software development, interface design, and usability testing would be an iterative process. Furthermore, the image dataset used in the prototype was limited to the images supplied by the project participants¹² and as such presented a restricted and non-representative set of returned images for each search. We can speculate that if search could be carried across the vast and varied images found across all GLAM collections in the UK, the returned images would be more relevant and interesting to users.

In summary, users were interested in having an understanding of the scale of the image collections that they could search across, as well as the ability to aggregate, curate, and save their own ‘collections’ from different institutions in one place. Metadata and re-use permissions were key for all testers, as was the ability to navigate to the collection website from whence the images originated so as to gain more context and information. We found that testers struggled to both understand and employ the XAI technology – all users found the heatmaps confounding though fascinating (what the AI finds similar is quite different to what our testers found similar between images). The ability to enter into a dialogue with the AI through modifying the returned images was also not picked up by the testers, though this may be attributed to the prototype design and novelty of the technology. It is likely that this development will either require more on-boarding for uptake or should be made ‘invisible’ to the user in a way that creates a seamless experience. Most of the testers intuited both the annotation tool that allowed them to select specific areas for searching, as well as searching with several images simultaneously. The latter option seemed natural to our testers, and some commented that they rarely approach a search or browse situation with only one image or a singular visual feature in mind. The multi-image search option also allowed for creative deployment of the technology, with some users expressing an interest in searching with drastically different images (to their eye) or in selecting very large numbers of images for their search set.

¹² Though all four Project Partners supplied image sets, only one of these could be displayed in the final prototype, as the rest belonged to private or commercial collections.

In terms of further developments, most testers highlighted the benefit of refinement by (1) negative filtering (e.g. ‘show *less* like this result’); (2) mixed visual and semantic search, for example by additional filtering based on media type, time-period, location, collecting institution, type of collection; (3) semantically articulated well-defined visual facets like ‘colour’. Most users felt that the technology was better suited to exploratory search rather than task-driven search, though again, this may be due to the restricted image data set available for testing. Computer vision search was welcomed by all users as an exciting addition to their search and discovery tasks. Testers highlighted the potential of this technology for enabling search and discovery for users with certain disabilities like dyslexia, or for lowering access barriers for non-native English speakers and those users who lack technical language to describe their query. Users with prior experience of computer vision search through platforms like Google, Amazon, and e-Bay also highlighted that they (1) had more trust in the images and metadata returned in an institutionally-driven search platform, and (2) liked the lack of commercially-driven motivation in the returned results.

Project Outputs

Data from the project survey, unmoderated testing, as well as the background UX literature report can be found in the Annexes of this report. Examples of our user case studies as well as the methodology for developing the functionality of the platform are also described in the Annexes. A long-form video of the interface design process is available on YouTube.⁹ Recordings of the project interim progress presentation,¹³ engagement event on CV in Heritage Collections webinar,¹⁴ and closing webinar¹⁵ are all available on the Towards a National Collection YouTube channel. Our project’s interim report can be found on the Towards a National Collection website.¹⁶ Our first blog post is available on The National Archives website¹⁷ and the Europeana AI in relation to GLAM taskforce report¹⁸ is also available online. Most of the talks and posters presented by project members were invited and did not require an abstract. Our submission to the DARIAH 2021 Annual Event on Interfaces can be seen below.

Deep Discoveries joins HEI-based computer vision experts, GLAM professionals, and UX researchers to explore the opportunities afforded by AI-enabled visual similarity recognition technologies for cross-collection image searching. A central aim of the project is the delivery of a prototype to demonstrate the ‘research’ and ‘discovery’ potentials of a novel technology to multiple types of users. The complex goal of bridging diverse user searching tasks was further complicated by the distinct drivers of our transdisciplinary team. A critical intervention occurred at the interface design stage, with the integration of a Design Research team and the development of a shared vision and a joint vocabulary. The interface design served to cultivate a balance between advancements in computer vision technology and existing end-user knowledge, skills and adaptability. Our teams came to view the interface as a boundary object, a tool that enabled, if not an agreement on the research approach, then certainly a shared understanding and way forward. We propose that the interface can serve as a site for collaboration across the TaNC programme, mediating the distinctive drivers and professional demands of all

¹³ <https://m.youtube.com/watch?v=rE1crHZCRd0&t=3095s> accessed 02/09/2021

¹⁴ <https://youtube.com/playlist?list=PLRixrpy54RHY3HduZtjUHitslGI8lljFb> accessed 02/09/2021

¹⁵ <https://www.youtube.com/watch?v=h9J16YbsLao&list=PLRixrpy54RHZbkN4GVqAaLelZh84J524b> accessed 02/09/2021

¹⁶ <https://www.nationalcollection.org.uk/Foundation-Projects> accessed 02/09/2021

¹⁷ <https://blog.nationalarchives.gov.uk/deep-discoveries-exploring-a-new-way-of-discovering-and-connecting-digitised-collections/> accessed 02/09/2021

¹⁸ <https://pro.europeana.eu/project/ai-in-relation-to-glams> accessed 02/09/2021

stakeholders, from the complex needs of specialist researchers and requirements of heritage organisations, to the discovery-driven demands of general audiences.

A Case Study for the Human Computer Interaction conference was also submitted, based on the contents of this report. The abstract for this short paper:

This case study reports on the design process and outcomes of Deep Discoveries, a cross-sectoral investigation into the application of computer vision visual search to the design, software development, and user experience of a heritage discovery search platform. The platform enables searches across some of the United Kingdom's digitised image repositories, harnessing computer vision methods to identify and recognise visual patterns. Rather than relying on integrated descriptive metadata, searching is based on visual attributes such as pattern and motif, promoting discovery of unforeseen connections within and between image collections. Deep Discoveries is informed by digital heritage research that aims to liberate large cultural datasets from the constraints of searching large collections 'blindly' through keywords entered into a search box. The case study outlines the design process of applying visual search functions to human centred experience design with the aim of engaging users in a visual dialogue with the AI-driven system. It goes on to discuss findings, reflections and challenges, and future research opportunities.

The Deep Discoveries project webpage¹⁹ and GitHub page²⁰ will remain active for the duration of the Towards a National Collection research programme. GitHub also contains patched-based vision approach supporting the backend of the project²¹ and the frontend code supporting the live demo website.²² Two peer-reviewed manuscripts are planned for the project – one discussing the AI developments by the UoS team and one on the XAI and UX research carried out by all partners.

Recommendations for the programme

Our UX research and engagement activities demonstrated a unanimous interest in visual search both for general discovery of collections and for specialist research activities. The ability to search using existing images in collections or with new content created/uploaded by users as well as to visually articulate attributes within images of interest was noted as desirable in the context of a national cross-collection platform. We can therefore recommend that computer vision technologies, and specifically visual search, be integrated in any future platform that aims to support user discovery of GLAM collections. However, visual search is insufficient for most users' needs. An integrated system that allows users to carry out image retrieval using both visual search and semantic filtering (based on existing or newly generated metadata) would be better suited for most tasks.

We tested seven convolutional neural networks for the backend image processing. However, within the confines of our project, we were not able to deploy each of these and obtain user feedback on their individual accuracy, relevance, or efficacy using the live prototype. Further research into whether users prefer one model over the others, or into how (or if)²³ multiple CV search models can be

¹⁹ <https://tanc-ahrc.github.io/DeepDiscoveries/> accessed 02/09/2021

²⁰ <https://github.com/tanc-ahrc/DeepDiscoveries/> accessed 02/09/2021

²¹ <https://github.com/tanc-ahrc/deep-discoveries-backend/> accessed 23/09/2021

²² <https://github.com/tanc-ahrc/deep-discoveries-frontend/> accessed 23/09/2021

²³ Whether the AI 'reasoning' component of such a search platform should be made explicit is a cultural and political question, and speaks to current research around Human Data Interaction, a conceptual framework for ethical systems design. Although many commercial systems offer a seamless integration of these technologies that users find appealing (if aware of them at all), they are also problematic in that they defer human agency and judgement to a black-box technology.

seamlessly integrated into a user interface is necessary. As noted in the results section, many users did not fully understand or find necessary the XAI aspects of the platform as they were presented in the current interface. Whether this is a result of the interface or of the technological development itself remains to be explored. We believe that with further refinement of the frontend presentation of the technology along with a larger image dataset that better demonstrates the capacity of CV search, users would be more likely to iteratively engage with the XAI system.

All engagement, surveying, and testing activities carried out in the project demonstrated that users require not just images, but written information about the images (e.g. context, re-use and copyright details, resolution options, provenance, location). As collecting institutions embark on digitising more of their collections for online discovery, accessible and visible workflow guidelines on generating standardised metadata should be made available and/or be better publicised and disseminated. In terms of accessing and using collection images for visual search, recommendations for imaging standards should also be provided. Our project also found barriers around proprietary collections, or collections that have been digitised by 3rd party commercial partners. Some organisations would like their collections to be searchable and discoverable by new audiences and researchers; however, that would interfere with their commercial ambitions or income streams.

Many of our testers noted that they trust images,²⁴ and the associated contextual information, obtained from institutional websites and/or through a theoretical cross-collection search platform. This trust comes with a responsibility on the part of organisations for transparency in their collecting, digitising, and sharing practices. A CV search algorithm will surface those collections that have already been made available, and will do so according to the training process it was developed with. This means that we have a responsibility to critically assess which visual collections are made available to the general public under the banner of a 'national' collection by virtue of being at the top of the digitisation priority pile, and whether these images are truly representative of the breadth of visual content created by, with, or about our communities. We also must be transparent with users on how CV search models are trained, and clarify that visual similarity may hold different meaning to different individuals. As noted earlier, whether training and annotation by different participants would generate models that yield differently ranked image results remains to be tested. Alternatively, the development of CV search algorithms that can be re-trained by individual users as they carry out their search tasks could bypass the training bias problem altogether.

As noted earlier, CV search offers opportunities for enabling search and discovery for users with certain disabilities like dyslexia, or for lowering access barriers for non-native English speakers and those users who lack technical language to describe their query. However, CV search is a technology reliant on visual input. Hence, when speaking of diversifying audiences or ways of engaging, we must consider users who may be visually impaired, and instead rely on Image Descriptions (ID). If organisations would like to use CV search, more work should be focused on ensuring IDs are available for visual collections, and research into linking these with the visual search results should be carried out. Here again, machine learning can be employed to expedite this process.²⁵

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²⁴ This is particularly interesting, when we consider the current trend in deep fakes

²⁵ Brownlee, Jason. How to Develop a Deep Learning Photo Caption Generator from Scratch (2019) <https://machinelearningmastery.com/develop-a-deep-learning-caption-generation-model-in-python/> Acc. 11/12/2020

Annex 1: User Research

The UX research comprised semi-structured interviews, a workshop and desk research, giving several perspectives on the subject. Due to Covid-19 restrictions, the workshop and interviews were held remotely. The research questions were four of those listed under the project's 'User-related' work package (WP2):

- Who uses digital graphic collections and who is excluded?
- What are the real and perceived barriers to user access and discovery of these collections?
- What are the ethical implications of applying visual search to heritage collections?
- How can we avoid perpetuating bias and colonial practices in the virtual realm, how can we engage more diverse audiences with our collections?

The question 'What measurables can we define to evaluate the success of the proposed technological advancement?' was not addressed in this part of the research.

Interviews: Interview participants were people working in various fields of design. Five people were interviewed via Zoom. Interviews began with a semi-structured conversation around participants' job roles and how they went about finding inspiration for their designs. This led on to learning how they searched for digital images: what exactly they were looking for, which tools they used, how useful these were and how the experience could be used. At the end of the interview, participants were shown a wireframe of a visual search page. This conveyed the concept of visual search and allowed exploration of how users might expect to interact with it, and what 'facets' they might want to filter results by.²⁶

Google Image search (in the sense of searching for images by keyword, rather than visual search) had been used most often by participants to find images. One participant had used Google Reverse Image (a visual search), generally when looking for the origins of an image, that is the story behind it, who owned it, what era it was from, and to understand the original elements within the image, such as colour, texture and materiality. With the exception of colour, facets presented within the wireframe meant different things to different participants.

Insights from the interviews fed into the workshop and survey design, and have informed the development of prototype design.

Workshop: The workshop was inspired by a V&A workshop exploring the users and uses of their own digital collections, which aligned well with the research questions.²⁷ People responsible for collection engagement were invited from Deep Discoveries collaborators and partners. The workshop sought to understand who engaged with the collections and how they were used, and to explore potential ways that visual search of a national collection could help to broaden access.

The remote nature of the workshop limited normal interactions between participants and made it difficult to provide the fun elements that can help participants to relax into the setting, as well as risking screen fatigue. To mitigate these problems the workshop was limited to 2.5 hours and 12

²⁶ By 'facets' we mean single dimensions of a multi-dimensional search. In the context of visual search, facets might include quite concrete visual characteristics such as "colour" or "brightness", through more abstract characteristics such as "depth of field", to abstract concepts such as "theme".

²⁷ Jack Craig, 'How Are the V&A's Online Collections Used?', *V&A Blog*, 2019

<https://www.vam.ac.uk/blog/digital/how-are-the-vas-online-collections-used> [accessed 4 December 2020].

participants, split between 3 breakout groups. It took place in two parts with a break between. FunRetro was used as a collaboration tool for the workshop: this simple tool allowed everyone to share ideas with minimal upskill time for new users.²⁸

The first part addressed the first two research questions ‘Who uses graphic collections and who is excluded?’ and ‘What are the real and perceived barriers to user access and discovery of these collections?’ It consisted of presentations about the project and its objectives and overviews by three experts of their own collections, addressing some of the points that the workshop sought to uncover. The questions were discussed in three breakout sessions and the responses fed back to the group as a whole.

The second part consisted of a presentation on visual search and insights from the interviews, to get participants thinking about both how visual search could help with interview participants’ challenges and the benefits of accessing a national collection, addressing the latter two research questions ‘How would users benefit from visual search of a national collection, what are the barriers/limitations?’ and ‘How might visual search help users overcome existing barriers and help reach new audiences?’ In this session a single FunRetro board was used across all three sessions, allowing participants to see ideas from other breakout sessions. This allowed us to avoid repetition and to build on ideas.

Desk Research: The final part of the UX research was a limited literature review. The purpose was not to perform a full literature review but rather to learn enough to inform design of a prototype visual search system, particularly with respect to potential use cases and interfaces. Readings came mainly from a list that one of the team had built up over the past few years: many were academic papers, but blog posts and magazine articles were also included. We also looked at some existing digital image collection platforms, both with and without visual search features.

Readings and platforms were recorded in a Trello board and key insights were summarised on a Miro board.²⁹

Summary of Research: From the limited evidence of these readings, it seems that there are differences between institutions and/or collections in both online audience makeup and the uses that audiences are making of the collections. Many users are engaged in specific tasks to reach a desired goal and ‘just browsing’ seems not to be a common activity.³⁰ Audiences may be best understood in terms of particular characteristics: one study suggests that technical and subject expertise may be the most useful characteristics, but others are mentioned, including available time for the task, work vs leisure activities, and age.³¹ Users have certain expectations of digital systems shaped by popular

²⁸ Since renamed *EasyRetro* <<https://easyretro.io/>> [accessed 4 December 2020].

²⁹ ‘Deep Discoveries Reading’, *Trello* <<https://trello.com/b/F5YYEHCC/deep-discoveries-reading>> [accessed 3 August 2021]; ‘Deep Discoveries Research’, *Miro* <https://miro.com/app/board/o9J_knq9_dI/> [accessed 3 August 2021]. Numbers tagged on to Miro notes refer to sources in Trello.

³⁰ Craig; Julia Falkowski, ‘Custom Collections Content and Generous Interfaces’ (presented at the MW2016: Museums and the Web 2016, Los Angeles, 2016) <<https://mw2016.museumsandtheweb.com/paper/custom-collections-content-and-generous-interfaces/>> [accessed 30 July 2020]; Paul Clough and others, ‘Europeana: What Users Search for and Why’, in *Research and Advanced Technology for Digital Libraries*, ed. by Jaap Kamps and others, Lecture Notes in Computer Science, 2017, pp. 207–19 <https://doi.org/10.1007/978-3-319-67008-9_17>. On “just browsing” specifically, the highest level of browsing we have seen is in Falkowski, who cites research on Dutch museum websites finding 21% casual browsing vs 29% specific information seeking. Of course, different studies do not necessarily have a common definition of “browsing”.

³¹ David Walsh, Paul Clough, and Jonathan Foster, ‘User Categories for Digital Cultural Heritage’, in *Proceedings of 1st International Workshop on Accessing Cultural Heritage at Scale* (presented at the ACHS’16, Newark, NJ, USA, 2016) <<http://ceur-ws.org/Vol-1611/paper6.pdf>>.

digital platforms, but different kinds of audiences will have varied expectations for the platforms and interfaces used and might want to engage with collections content in different ways and will be seeking to accomplish different kinds of tasks.³² For example, subject matter experts may need different information to more general users. The ‘correct’ way to segment an audience depends upon what one wants to do with one’s findings. From a UX perspective, segmenting audience by motivation and behaviour is often most useful to inform design decisions, while age and other demographics may be more useful to understand who content is reaching and who is included or excluded.

Interfaces which encourage exploration through recommendation may be useful for increasing appeal to their users, and are a style of interface that may be comfortable for users used to other systems for sharing content at scale such as Spotify. However, such interfaces also risk giving users a very narrow view of the collection, trapping them in a filter bubble.³³ The workshop noted that framing is important, giving the example that a research guide framed around IP searches will tend to lead to a collection being used for that purpose at the expense of other purposes to which it might be suited. All this implies that multiple interfaces would be helpful to making use of a collection in different ways.³⁴

Audiences known to workshop participants tend to be of a particular type, as the participants represented design collections. This gives us one relevant view onto audiences for visual collections. Audiences for these collections include historical and intellectual property researchers but also ‘creatives’ and art students: both of these latter types like to see many examples of the collection’s holdings, either to spark inspiration or because this is encouraged by their tutors, a task that may be enhanced by the ability to search a national collection. Users of commercial design archives may seek to reuse designs for branding or to tell stories for sales.

A part of one participant’s audience had followed a collection which used to be elsewhere. As well as reminding us that audiences are not fixed and can change over time, this also highlights that collections themselves are not static, but can move, change and split. One interviewee suggested that visual search might help to recover a lost archive. Cross-collection visual search may be helpful in dealing with the shifting boundaries of collections.

³² Clough and others; Craig; Falkowski; Walsh, Clough, and Foster; Villa Villaespesa and John Stack, ‘Finding the Motivation behind a Click: Definition and Implementation of a Website Audience Segmentation’, 2015 <<https://mw2015.museumsandtheweb.com/paper/finding-the-motivation-behind-a-click-definition-and-implementation-of-a-website-audience-segmentation/>> [accessed 4 August 2021]; Constance Grady, ‘How the SFMOMA’s Artbot Responds to Text Message Requests with Personally Curated Art’, *Vox*, 2017 <<https://www.vox.com/culture/2017/7/11/15949872/sfmomas-artbot-send-me-text-message>> [accessed 12 August 2020].

³³ Falkowski makes the comparison with Spotify and other systems and also indicates that it is incumbent on educational institutions to be aware of, and perhaps to burst, filter bubbles. Sayantan Hore and others, ‘FutureView: Enhancing Exploratory Image Search’ (presented at Joint Workshop on Interfaces and Human Decision Making for Recommender Systems, INTRS 2015 - In conjunction with the 9th ACM Conference on Recommender Systems, RECSYS 2015 - Vienna, 2015), *CEUR Conference Proceedings*, 1438 (2015), 37–40, note bubbles as a risk in visual search that uses relevance feedback.

³⁴ Tim Sherratt, ‘Hacking Heritage: Understanding the Limits of Online Access’, in *The Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums and Heritage Sites*, ed. by H Lewi and others (London: Routledge, 2019), p. 16 <https://timsherratt.org/assets/images/Sherratt_GLAM_Digi_AAM.pdf>, makes reference to a suggestion of the value of many interfaces. Kati Price, ‘Redesigning the V&A’s Collections Online’, *V&A Blog*, 2019 <<https://www.vam.ac.uk/blog/digital/redesigning-the-vas-collections-online>> [accessed 4 August 2021] mentions showing objects in many contexts.

It may be possible to increase awareness of digital collections and to engage more diverse audiences by broadening the offering. Institutions have attempted to engage more collaboratively with users through crowdsourcing or social media challenges and we can allow users to create their own collections or even to produce their own interfaces, opening up both another form of engagement and perspectives from outside the sector.³⁵ Such engagements can be built on visual search, among other methods. Connecting collections in these and other ways has the potential to improve diversity: examples raised at the workshop, in the context of a national collection, include connecting the audiences of different collections and the possibility of drawing in non-specialists who are curious about the visual culture around them. Both non-specialists and artificial intelligences may make observations or connections that curators would not, again providing new ways of looking at connections and thus some potential to draw in new audiences, although this carries with it risks of problematic or nonsensical associations.³⁶ Workshop participants mentioned concerns about lack of context and the potential for misunderstanding the search's connections, as well as raising questions about the search being able to match only parts of the object's appearance, such as surface patterns. Whether any given cross-cultural connection enriches our understanding or, rather, seems to impose one culture upon another, should also be considered carefully, as should sensitivities around the provenance of items in a collection -- in the case of visual search, we particularly need to be aware of better AI performance at making sense of Western culture.³⁷ Comments from the workshop suggest that making connections between different collections can improve our understanding of cultural associations and influences and that artefacts from former colonies can be used as one way to reach out to new audiences. They also suggest that a national collection may make it possible to lower the barriers to discovery of a specific image and of seeing how an image and its depiction have evolved over time, and that the ability to connect images across collections creates the possibilities both of filling in gaps in individual collections and of adding context to collections.

The most obvious barriers to access to physical collections are that their audiences need to be able to physically reach them, and often to be willing and able to deal with the collections' gatekeepers.³⁸ Workshop participants noted these and other barriers, including difficulties around access to vulnerable or toxic material and -- particularly noting that opening times for collections often fall within office hours -- the need for sufficient money and time to visit. Casual interest is particularly excluded for archives such as these as people cannot so freely come and go, or choose to engage in 'lighter' ways, and may even feel that archives are not for the public. Digitisation opens the collections up to those without the time, money or confidence to visit physical collections: provided, of course, that they have the access to the required technology, and the ability to use it.

A particular issue is user knowledge. Some interview responses mention the value of expertise in and memory of the collection, and of understanding of cataloguing systems, while a workshop participant

³⁵ Falkowski; Sherratt; Rachel High and Amy Liebster, 'One Met. Many Worlds. and The Metropolitan Museum of Art Guide', 2014 <<https://www.metmuseum.org/blogs/now-at-the-met/2014/one-met-many-worlds-and-the-met-guide>> [accessed 6 August 2021]; Brad Jones, 'Computers Saw Jesus, Graffiti, and Selfies in This Art, and Critics Were Floored', *Digital Trends*, 2018 <<https://www.digitaltrends.com/computing/philadelphia-art-gallery-the-barnes-foundation-uses-machine-learning>> [accessed 12 August 2020].

³⁶ High and Liebster; Jones; Brendan Ciecko, 'AI Sees What? The Good, the Bad, and the Ugly of Machine Vision for Museum Collections' (presented at MW20, online, 2020) <<https://mw20.museweb.net/paper/ai-sees-what-the-good-the-bad-and-the-ugly-of-machine-vision-for-museum-collections/>> [accessed 30 July 2020] is a helpful source on, among other things, bias and ethics in machine vision applied to cultural heritage, and also describes some (mostly poor) cases of machine observation.

³⁷ Again, see Ciecko. Jones' description of the Barnes Collection indicates that it highlights connections across cultures.

³⁸ Sherratt.

noted that curators need to engage in a dialogue to match what people are looking for with what the collection has to offer. Less knowledgeable users are less able to make use of catalogues or to ask questions of curators. In the digital context, this is particularly apparent in traditional search. The search box is unhelpful for users who are not searching for something specific and technical vocabulary may be required to make the best use of it.³⁹ Visual search can mitigate this problem, as can interfaces that suggest terms and give visual cues or rapid feedback to give an intuitive sense of the terms' meaning. Sensemaking tools are one example of this.⁴⁰ Here we mean tools which allow search items to be clustered together, both creating a visual impression of examples of a single concept and displaying the common metadata of the items. This provides some terminology to help the user to verbalise the concept that they are forming. As the cluster changes, so does the common metadata that describes it. Such tools might be seen as providing a form of dialogue between the users and the collection. While this dialogue between user and machine would be much less rich than dialogue between user and human expert, it has the benefit of being open to those without the confidence or time to engage with a human expert, and perhaps of building their confidence and their vocabulary to engage more effectively with human experts.

Scale presents some problems beyond just the obvious one of knowing where to begin looking. It can also be misleading, giving an impression of comprehensiveness where in fact what is digitised may be merely one part of one collection.⁴¹ Workshop participants noted that neither documentation nor digitisation are ever complete. They also noted (converse to the impression of comprehensiveness) that limited digitisation may give the impression that a collection is smaller than it really is. Users may falsely assume that searches find everything of relevance in the collection. There is also a risk that connections made by a search tool will be assumed to be valid, an issue which is especially a problem where the connection might be perceived to have the authority of the host institution.⁴² Where material is returned, it may not be of the quality that the user needs, or in the form that they need it. On the other hand, if we can construct the interfaces required to address a collection at its full scale, it becomes possible to 'address the meaning of a collection *as a collection*.'⁴³

Metadata provides useful information for users, giving context to items in a collection. The availability and quality of metadata limits both the effectiveness of traditional 'search box' search and our ability

³⁹ Falkowski; Mark M Hall, 'From Searching to Using: Making Sense of Digital Cultural Heritage Collections' (presented at The Search Is Over! Exploring Cultural Collections with Visualization, London, 2014) <<https://searchisover.org/papers/hall.pdf>>. Hall (section 1) refers to sources on the need for knowledge (and 'a focused information need') to make use of search box interfaces.

⁴⁰ Hall; Hore and others; Christopher Power and others, 'Improving Archaeologists' Online Archive Experiences Through User-Centred Design', *ACM Journal on Computing and Cultural Heritage*, 10.1 (2017), 3:1-3:20 <<https://doi.org/10.1145/2983917>>.

⁴¹ Sherratt, who also points out that collections themselves have biases and absences long before they become digital.

⁴² Craig points out both that users in observations would assume that the first search hit gave all of the V&A's website's information on an object, and that the perception of the V&A creates an obligation to be 'clear and transparent about the accuracy of the information that we provide.' Harini Suresh, Natalie Lao, and Ilaria Liccardi, 'Misplaced Trust: Measuring the Interference of Machine Learning in Human Decision-Making', in *WebSci '20: 12th ACM Conference on Web Science* (Southampton, UK, 2020), pp. 315–24 <<https://doi.org/10.1145/3394231.3397922>> describe an experiment in misplaced trust in AI systems, referring to other literature on the problem. While the context is different, this is a phenomenon worth bearing in mind. Falkowski and Ciecko both point out the invisibility of undiscoverable objects. Sherratt, p. 10, notes that the visibility of an object, and the form in which it is made visible, determine how the collection is experienced.

⁴³ Sherratt, p. 8.

to supplement visual search with traditional methods.⁴⁴ Errors in metadata are a particular problem for cultural institutions, as their authoritative status behoves us to get the metadata right.⁴⁵ It will also not be consistent across collections.⁴⁶ While cross-collection standardisation might be a solution to this, it may not be desirable or even feasible at the level of metadata. Visual search is not dependent on metadata and so does present one solution to this problem.

One important item of metadata is the provenance of an item in the collection, and the intellectual property rights applying to it: where did it come from, on what basis is it in its current collection, who holds the rights to the image and what is the user allowed to do with it? This comes out strongly in the interviews where it seems that interviewees are often able to find inspiration using existing tools and keyword searches but that questions of provenance are hard to answer. Generous interpretations of creators' rights may unduly limit the rights of users.⁴⁷ Presumably, the inverse holds too. Failing to provide this information may fail to recognise disputes over the rights to hold an item, and leaves users unable to know whether and how they are able to reuse an image. Outside of the copyright system, consent to the inclusion of an item in a collection can also be important.⁴⁸ Clarity about intellectual property is essential to permitting user-created content. While IP information is important outside of digital contexts, the ease of replication and reuse of digital content makes the issue especially relevant.

Interfaces constrain the kinds of questions that can be asked and the kinds of answers that can be given.⁴⁹ Tools offering search through predefined terms, limit search queries to those that can be constructed with those terms. Results structured in terms that make sense to experts or reflect institutional structures may be difficult to navigate for many users, contributing to exclusion of those who are outside of academia or the cultural sector. This highlights the importance of user research as systems designed by experts and institutions are likely to reflect the needs of those experts and institutions, which may be different from those of the target audience. This point is also relevant to physical collections: a workshop observation was that users of physical archives have to negotiate its systems, whether or not these are digital. The issue takes a particular shape in the digital case, however, as the systems become more widely available but any communication seeking help from experts also has to be digital.

Finally, the workshop noted that users cannot use a collection if they do not know that it exists, that access is not restricted to some exclusive group, and that it is useful to them (for example, framing a collection as 'design' vs 'social history' will draw in different audiences). The ability to search across collections may help with this problem of discovery, especially where the metadata is helpful in directing the user back to the source collection and in describing the terms of use of the image. Integration with well-known generic search interfaces, such as Google, and with other platforms, may also be helpful in surfacing the existence of a collection.⁵⁰

⁴⁴ Ciecko.

⁴⁵ Craig.

⁴⁶ Price, for example, notes this problem in the V&A's collections.

⁴⁷ Falkowski, notes this as an issue for online audiences and presents the Rijksmuseum as an example of a successful approach to openness. Price does not mention IP but does mention support for 'making' as an important goal. Sherratt refers to opportunities to create as well as to consume.

⁴⁸ Sherratt.

⁴⁹ Sherratt, p. 4, mentions the constraint of interfaces in the particular context of what can be done with the items found via an interface.

⁵⁰ Falkowski mentions both the importance of Google, and the Rijksmuseum's connection to Etsy. Craig notes that much of the V&A's traffic comes from search engines. Tom Steinberg, 'The Internet of Heritage: A Future',

Conclusion: Returning to the research questions listed at the beginning of this document, we have seen that the users of digital graphical collections are a varied group. We do not have a clear view of who is excluded but we have considered some barriers to access. We do not have a clear sense of how to avoid bias, but we can see that it is possible to provide access to collections in diverse ways that should broaden access and discovery. Some ethical issues have been indicated, such as issues of rights, risks of problematic juxtaposition and bias in AI and the importance for authoritative institutions to communicate clearly and correctly. We can add the need to provide access to people with disabilities, such as the visually impaired. Such issues should be addressed now, while we are at the beginning of what will likely be a wider deployment of ever more powerful digital and AI techniques over the coming years.⁵¹

We can consider what all of this means for designing a prototype, cross-collection visual search. While there may be some kind of generic similarity, it seems likely that similarity will depend to a greater or lesser degree upon the task: different audiences, involved in different tasks to accomplish different things for different reasons, will be looking for images which are similar in some particular respect.⁵² Search systems may be limited to identifying certain kinds of similarity: neural networks, for example, must be trained by humans following some (implicit or explicit) definition of similarity. In designing a system we must consider the audiences and their goals, motivations and tasks: none of these can be considered in isolation, but must all be understood together.

This implies that collections may be best approached by offering a range of tools for a range of audiences and tasks. Different interfaces will be more effective for particular tasks and goals and can appeal to different points in the space of users, goals, motivations and tasks. For example, a highly complex interface allowing very detailed search queries might be suitable for an expert user seeking out very specific information, while a simple interface that searches out broad, generic groupings might be better suited to more casual or less expert users. To design a successful prototype, we must focus upon a particular class of user with a genuine need to engage in cross-collection visual search, to create both a search and an interface that succeeds in being useful for a specific purpose. However, in focusing on one narrow use case it is often possible to benefit a wider segment as needs for different goals and tasks overlap.

2020 <<https://tomsteinberg.wordpress.com/2020/06/08/the-internet-of-heritage-a-future/>> [accessed 9 August 2021] argues for making metadata available in forms that the large technology companies can integrate with.

⁵¹ Ciecko.

⁵² Melvin Wevers and Thomas Smits, 'The Visual Digital Turn: Using Neural Networks to Study Historical Images', *Digital Scholarship in the Humanities*, 35.1 (2020), 194–207 <<https://doi.org/10.1093/lhc/fqy085>>. Different kinds of similarity are particularly noticeable in this paper, with three different systems for finding different kinds of similarity. 'Barnes Collection Online' <<https://collection.barnesfoundation.org/>> [accessed 9 August 2021] is an example of an interface which makes explicit different kinds of visual similarity.

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Annex 2: Deep Discoveries Survey Data

1. Have you ever looked for visual inspiration? (e.g. to look at a collection of objects, photographs, works of art, something in nature, an object, a building etc. to get an idea for something or build on an idea you already have)

		Response Percent	Response Total							
1	Yes		93.40% 198							
2	No		6.60% 14							
Statistics	Minimum	1	Mean	1.07	Std. Deviation	0.25	Satisfaction Rate	6.6	answered	212
	Maximum	2	Variance	0.06	Std. Error	0.02			skipped	0

2. Which , if any, of the following have you visited in person or online to look for visual inspiration? (you may choose more than one option)

		Response Percent	Response Total
1	Museum		85.50% 171
2	Gallery		76.00% 152
3	Library		67.00% 134
4	Archive		65.00% 130
5	Botanical Gardens		45.50% 91
6	None of the above		5.50% 11



Statistics	Minimum	1	Mean	2.78	Std. Deviation	1.42			answered	200
	Maximum	6	Variance	2.03	Std. Error	0.05			skipped	12



3. When looking for visual inspiration, how often have you visited any of the places listed above in person or online?



									Response Percent	Response Total
1	Once								2.67%	5
2	Less than 5 times a year								36.90%	69
3	On average, once a month								30.48%	57
4	On average, twice a month								12.30%	23
5	At least once a week								17.65%	33
Statistics	Minimum	1	Mean	3.05	Std. Deviation	1.14	Satisfaction Rate	51.34	answered	187
	Maximum	5	Variance	1.3	Std. Error	0.08			skipped	25

4. Generally, what motivated you to look for visual inspiration (either in person or online) at any of the places you selected above?







									Response Percent	Response Total
1	Work/Study								19.25%	36

2	Personal Interest/Hobby		19.25%	36						
3	Both		61.50%	115						
Statistics	Minimum	1	Mean	2.42	Std. Deviation	0.79	Satisfaction Rate	71.12	answered	187
	Maximum	3	Variance	0.63	Std. Error	0.06			skipped	25

5. Do you work/study in a field of Design/Visual Art and/or Media?										
									Response Percent	Response Total
1	Yes		52.63%	80						
2	No		47.37%	72						
Statistics	Minimum	1	Mean	1.47	Std. Deviation	0.5	Satisfaction Rate	47.37	answered	152
	Maximum	2	Variance	0.25	Std. Error	0.04			skipped	60

6. Which field of 'Design' do you work/study in? (you may choose more than one option)										
									Response Percent	Response Total
1	Fashion		15.00%	12						
2	Art		48.75%	39						
3	Film/Video		20.00%	16						

4	Gallery/Exhibition/Museum Curation		22.50%	18
5	Architecture		8.75%	7
6	Graphic Design		17.50%	14
7	Interior Design		11.25%	9
8	Jewellery		3.75%	3
9	Product Design		13.75%	11
10	Textile Design		13.75%	11
11	Wallpaper Design		5.00%	4
12	Furniture Design		8.75%	7
13	Ceramics		5.00%	4
14	Floral Design		0.00%	0
15	Landscape Gardening		2.50%	2
16	Animation		7.50%	6
17	Gaming		6.25%	5
18	Glass		2.50%	2
19	Make-up		0.00%	0



20	Printmaking		8.75%	7	
21	Theatre		2.50%	2	
22	Special Effects		0.00%	0	
23	Web Design		16.25%	13	
24	User Experience Design		17.50%	14	
25	Soft furnishings		2.50%	2	
26	Other (please specify):		27.50%	22	
Statistics			answered	80	
			skipped	132	
Minimum	1	Mean	10.83	Std. Deviation	8.83
Maximum	26	Variance	77.9	Std. Error	0.58

Other (please specify): (22)





1	28/01/2021 17:09 PM ID: 157900936	Archive collections
2	28/01/2021 17:12 PM ID: 157900512	photography
3	28/01/2021 18:40 PM ID: 157909821	People
4	29/01/2021 15:56 PM ID: 157991901	News / Factual Radio and TV
5	01/02/2021 13:08 PM ID: 158235947	Interaction Design
6	01/02/2021 18:55 PM ID: 158284404	Writing
7	02/02/2021 13:25 PM ID: 158344295	amateur (very keen) gardener

8	02/02/2021 14:14 PM ID: 158351141	creative engagement and individual value
9	02/02/2021 14:51 PM ID: 158356580	Technology design researcher
10	02/02/2021 14:56 PM ID: 158356814	Art history
11	02/02/2021 15:06 PM ID: 158358112	Digital Heritage Design
12	02/02/2021 15:10 PM ID: 158354267	interaction design, science and technology studies, human-computer interaction
13	03/02/2021 13:23 PM ID: 158436136	Design history
14	04/02/2021 14:08 PM ID: 158532975	Texts, too, seem to me to have shape, composition, scale, etc.
15	04/02/2021 14:54 PM ID: 158539813	Anthropology
16	04/02/2021 15:52 PM ID: 158547654	cartography
17	04/02/2021 16:00 PM ID: 158548806	Publishing, archives
18	04/02/2021 16:16 PM ID: 158550197	design history
19	04/02/2021 23:35 PM ID: 158582906	photography
20	06/02/2021 14:46 PM ID: 158695274	E-Learning Design
21	07/02/2021 10:15 AM ID: 158766407	musical instrument making
22	08/02/2021 20:44 PM ID: 158902238	Art and design archives

7. Have you ever looked for images online?

								Response Percent	Response Total	
1	Yes							99.53%	211	
2	No							0.47%	1	
Statistics	Minimum	1	Mean	1	Std. Deviation	0.07	Satisfaction Rate	0.47	answered	212
	Maximum	2	Variance	0	Std. Error	0			skipped	0

8. In general, how do you look for images online?

								Response Percent	Response Total	
1	I enter keywords into a search engine and then filter by images (e.g. 'Flowers' in Google and select 'Images' to view all the images of flowers)							31.75%	67	
2	I go straight to websites/apps I am familiar with to look for images							5.69%	12	
3	Both of the above							61.14%	129	
4	Other (please specify):							1.42%	3	
Statistics	Minimum	1	Mean	2.32	Std. Deviation	0.94	Satisfaction Rate	44.08	answered	211
	Maximum	4	Variance	0.88	Std. Error	0.06			skipped	1

Other (please specify): (3)

1	29/01/2021 01:38 AM ID: 157928475	I also look on particular collections websites
2	30/01/2021 18:16 PM ID: 158085814	both of the above but also sites and apps for context that might lead me to images I would have less expected to see
3	02/02/2021 13:25 PM ID: 158344295	browsing and disappearing down rabbit holes of lovely visual information

9. Which of the following, if any, have you used to look for images online? (you may choose more than one option)




			Response Percent	Response Total
1	Yahoo		4.27%	9
2	Google		96.21%	203
3	Bing		7.11%	15
4	Tineye		7.11%	15
5	Getty Images		39.34%	83
6	Flickr		38.39%	81
7	Pinterest		49.29%	104
8	Behance		7.11%	15
9	Shutterstock		20.38%	43
10	Instagram		47.39%	100

11	Other (please specify):						20.38%	43
Statistics							answered	211
							Minimum 1	
Maximum 11		Variance	9.78	Std. Error	0.12			
Other (please specify): (43)								
1	27/01/2021 14:34 PM ID: 157786330	pixabay, unsplash						
2	28/01/2021 10:52 AM ID: 157853050	cc sites						
3	28/01/2021 17:03 PM ID: 157900358	biodiversity heritage library						
4	28/01/2021 17:31 PM ID: 157903616	Britain from Above						
5	28/01/2021 17:45 PM ID: 157904838	Picture libraries and museum and archive collections						
6	28/01/2021 18:42 PM ID: 157910110	collections websites - eg. British Museum, V&A, Tate, also art.uk						
7	29/01/2021 01:38 AM ID: 157928475	collections websites, picture libraries, art UK, Europeana						
8	29/01/2021 09:11 AM ID: 157937423	Mary Evan picture gallery, other photo libuararies						
9	29/01/2021 09:55 AM ID: 157942184	Specific picture / photographic collections						
10	29/01/2021 10:05 AM ID: 157942834	Gallery-specific sites, eg V&A Collections						
11	29/01/2021 10:43 AM ID: 157945756	VADS, Art Uk and Bridgeman Images						
12	29/01/2021 14:55 PM ID: 157985109	Library of Congress						



13	29/01/2021 15:56 PM ID: 157991901	Unsplash
14	30/01/2021 00:25 AM ID: 158037310	Internet Archive
15	30/01/2021 06:45 AM ID: 158041274	Unsplash
16	30/01/2021 14:39 PM ID: 158073294	Artuk.org; bridgeman;
17	30/01/2021 18:16 PM ID: 158085814	over the years definitely a swathe of tumblr blogs, reddit pages, more specialist blogs
18	31/01/2021 11:50 AM ID: 158116732	pxfuel
19	31/01/2021 18:53 PM ID: 158175866	Mary Evans picture library
20	01/02/2021 08:29 AM ID: 158196801	archive.org
21	01/02/2021 09:51 AM ID: 158206938	Wikimedia Commons
22	01/02/2021 13:08 PM ID: 158235947	Tumblr, DuckDuckGo image search
23	02/02/2021 09:40 AM ID: 158316345	Pixabay
24	02/02/2021 10:38 AM ID: 158323108	Museum and archive image collections, e.g. Imperial War Museum, Science Museum Group
25	02/02/2021 14:16 PM ID: 158352179	DuckDuckGo
26	02/02/2021 14:23 PM ID: 158351211	Pixabay
27	02/02/2021 14:56 PM ID: 158356814	websites for specific museum/library/gallery/archive websites, as well as aggregators like ArtUK
28	02/02/2021 15:10 PM ID: 158354267	unsplash
29	02/02/2021 15:23 PM ID: 158360645	Online image libraries of individual heritage/culture organisations

30	04/02/2021 14:08 PM ID: 158532975	Duck Duck Go
31	04/02/2021 16:00 PM ID: 158548806	Various websites not specifically image based
32	04/02/2021 16:16 PM ID: 158550197	Picture Libraries like RIBA, Mary Evans, Historic England
33	04/02/2021 16:40 PM ID: 158554224	BFI, archives such as INIVA, Women's Art Library
34	04/02/2021 23:35 PM ID: 158582906	I use duckduckgo for all my search requirements
35	05/02/2021 23:07 PM ID: 158668681	Twitter
36	06/02/2021 14:46 PM ID: 158695274	Specific galleries, museums and apps from the Imperial War Museum, to Artsy, as well as the 14,000 images in my own Google Photos
37	10/02/2021 15:03 PM ID: 159052082	wikimedia commons
38	11/02/2021 12:33 PM ID: 159163565	Pixabay
39	11/02/2021 13:42 PM ID: 159183689	https://www.designspiration.com/ , personal or design blogs
40	11/02/2021 21:41 PM ID: 159254766	https://artvee.com/ , a list I have fortunately discovered : https://radiatorfa.com/index.php/11-sites-pour-de-superbes-photos-libres-de-droit-et-gratuites/
41	15/02/2021 08:56 AM ID: 159452605	Facebook; various university and museum image galleries
42	15/02/2021 09:36 AM ID: 159455944	MinDat, GB3D
43	15/02/2021 11:13 AM ID: 159465503	ART UK, IWM, VADS, NPG, V&A, NMM, NAM, Farleys Farm, Laura Knight Collection webpage...

10. What type of device do you tend to use most frequently when you look for images online?

		Response Percent	Response Total							
1	Smart phone (iPhone, android etc)		20.85% 44							
2	Tablet (iPad, Kindle etc.)		5.69% 12							
3	Laptop/Desktop Computer		73.46% 155							
Statistics	Minimum	1	Mean	2.53	Std. Deviation	0.82	Satisfaction Rate	76.3	answered	211
	Maximum	3	Variance	0.67	Std. Error	0.06			skipped	1

11. Have you ever used a 'Reverse Image Search/Visual Search' tool (this is where you upload/choose an image and you will be presented with identical/similar images e.g. 'Google Reverse Image' search)








		Response Percent	Response Total							
1	Yes		56.87% 120							
2	No		43.13% 91							
Statistics	Minimum	1	Mean	1.43	Std. Deviation	0.5	Satisfaction Rate	43.13	answered	211
	Maximum	2	Variance	0.25	Std. Error	0.03			skipped	1

12. How often have you used a 'Reverse Image Search/Visual Search' tool?

		Response Percent	Response Total							
1	Once	3.33%	4							
2	Rarely	40.83%	49							
3	Sometimes	39.17%	47							
4	Quite often	12.50%	15							
5	Very often	4.17%	5							
Statistics	Minimum	1	Mean	2.73	Std. Deviation	0.87	Satisfaction Rate	43.33	answered	120
	Maximum	5	Variance	0.76	Std. Error	0.08			skipped	92

13. Generally, why have you used a 'Reverse Image Search/Visual Search' tool? (you may select more than one option)

		Response Percent	Response Total
1	To find an identical match of an image I have	55.83%	67
2	To find a similar image to one I have	48.33%	58
3	To find out WHO created an image	55.83%	67
4	To find out WHEN or which era/time period an image was created	28.33%	34

5	To find out WHERE an image was created		25.83%	31
6	To get permission to re-use a specific image/understand copyright status		28.33%	34
7	To get an idea of the history of an image/story behind the image (How it came to be)		25.83%	31
8	To run a 'Prior Art' search i.e. to check how unique/original an image is by comparing it to other images		6.67%	8
9	To learn more about the subject matter captured in an image		30.00%	36
10	To find out who owns the image		25.83%	31
11	Other (please specify):		12.50%	15

Statistics	Minimum	1	Mean	4.75	Std. Deviation	3.11	answered	120
	Maximum	11	Variance	9.69	Std. Error	0.15		
								skipped


Other (please specify): (15)

1	26/01/2021 16:59 PM ID: 157709061	To find a better quality version of a printed image I already have
2	28/01/2021 17:04 PM ID: 157899687	To find out if an ad might be a scam, or if a personal photo has been stolen and used without consent
3	29/01/2021 01:09 AM ID: 157928257	for fun
4	29/01/2021 09:26 AM ID: 157938971	To see how well it worked
5	29/01/2021 14:52 PM ID: 157984838	To find another size of the image

6	01/02/2021 10:46 AM ID: 158214725	to find out if an image was copied from somewhere else
7	01/02/2021 13:01 PM ID: 158234530	Find same image in bigger size
8	02/02/2021 13:25 PM ID: 158344295	plagiarism checks (which aligns with the second bullet)
9	02/02/2021 14:56 PM ID: 158356814	mostly I've used it for my own photos - e.g. out on a walk and I want to identify a plant
10	02/02/2021 15:06 PM ID: 158358112	to find out for student plagiarism
11	03/02/2021 13:23 PM ID: 158436136	To find a version of the image with a different resolution
12	11/02/2021 13:42 PM ID: 159183689	to find a higher quality image of the same image
13	12/02/2021 08:10 AM ID: 159269573	To find other images that show similar items (such as a particular fashion style/silhouette/garment)
14	15/02/2021 08:56 AM ID: 159452605	To trace the recurrence of a printing surface, such as a woodblock or plate
15	15/02/2021 09:36 AM ID: 159455944	To find who has copied my organisation's images without attributing





14. When looking for identical/similar images, which elements do you find useful within the image to match/compare? (you may choose more than one option)

		Response Percent	Response Total
1	Colour composition	45.56%	41
2	Pattern (e.g. paisley, spotted, striped etc. - a repeated design/motif)	40.00%	36
3	Subject (e.g. an image which represents a leaf and you want to find all images with leaves - might even be quite abstract)	70.00%	63

4	Density/scale of detail (e.g. an image which is full of intricate details and you want to find all images with the same amount of detail, even though the design/pattern within the image itself might be different)		13.33%	12						
5	Composition of the subjects within the image (e.g. the arrangement of objects in relation to each other within an image)		31.11%	28						
6	Composition of shapes (geometric, organic or abstract) within the image (e.g the arrangement of shapes in relation to each other)		24.44%	22						
7	Technique/medium used to create an image (e.g. oil on canvas or black& white photography)		23.33%	21						
8	Images created by the same person (e.g 'Van Gogh', 'Renoir' etc. because of a particular style or technique used by the artist)		33.33%	30						
9	Images created by different people but of a similar style (e.g impressionist paintings by various artists)		32.22%	29						
10	Images which capture a common Theme/Mood/Topic (such as Joy, Anger, Sadness, Winter, Architecture, Forests etc.)		25.56%	23						
11	Images with common 'Elements of Art' (i.e. line, shape, texture, form, space, colour and value)		22.22%	20						
12	Other (please specify):		10.00%	9						
Statistics			Minimum	1	Mean	5.47	Std. Deviation	3.35	answered	90
			Maximum	12	Variance	11.21	Std. Error	0.18		
Other (please specify): (9)										

1	28/01/2021 17:12 PM ID: 157900512	colour dominance
2	29/01/2021 13:40 PM ID: 157973854	no idea!
3	02/02/2021 13:25 PM ID: 158344295	reverse image searching isn't very good unless there's an (almost identical) match
4	02/02/2021 15:06 PM ID: 158358112	it depends of what I am looking/researching for
5	04/02/2021 14:08 PM ID: 158532975	images that illuminate a challenging concept
6	08/02/2021 09:21 AM ID: 158821434	Repeat pattern structures
7	11/02/2021 09:05 AM ID: 159104866	I've only used it to find exact matches
8	11/02/2021 13:42 PM ID: 159183689	dont know
9	15/02/2021 09:36 AM ID: 159455944	Images of similar minerals, fossils, rocks for comparison and identification

15. Which 'Reverse Image Search/Visual Search' apps/websites have you used?- this is where you have uploaded or selected an image and your results are based on that image (you may choose more than one option)

			Response Percent	Response Total
1	Google Reverse Image Search		87.50%	105
2	Google Lens		22.50%	27
3	Tineye		22.50%	27
4	Pinterest Visual Search Tool		10.83%	13
5	Getty Images		5.00%	6

6	Shutterstock							3.33%	4
7	Bing Visual Search							1.67%	2
8	Other (please specify):							2.50%	3
Statistics								answered	120
								skipped	92
	Minimum	1	Mean	2.05	Std. Deviation	1.57			
	Maximum	8	Variance	2.46	Std. Error	0.11			

Other (please specify): (3)

1	30/01/2021 18:16 PM ID: 158085814	Amazon has a similar function now for product searches which I have tried out of interest in the technology. A lot of fashion sites are popping up that use similar algorithms
2	04/02/2021 16:00 PM ID: 158548806	Yandex
3	15/02/2021 08:56 AM ID: 159452605	Various VGG demos and implementations in book history (British Library; Bodleian Ballads; 15C Booktrade; Ornamento) and media (BBC News); BSB Image Search. I've also used VGG tools (particularly VISE) extensively on my own systems and materials.

16. Generally, what type of device have you used for 'Reverse Image Search/Visual Search'?

			Response Percent	Response Total
1	Smart Phone (e.g. iPhone, Android etc.)		21.67%	26
2	Tablet (e.g. iPad, Kindle etc)		4.17%	5
3	Laptop/ Desktop Computer		74.17%	89

Statistics	Minimum	1	Mean	2.52	Std. Deviation	0.83	Satisfaction Rate	76.25	answered	120
	Maximum	3	Variance	0.68	Std. Error	0.08				

17. Which statement below best describes your experience of using 'Reverse Image Search/Visual Search'?

									Response Percent	Response Total
1	I never really find what I am looking for, or anything of interest								5.83%	7
2	I rarely find what I am looking for, or anything of interest								18.33%	22
3	I sometimes find what I am looking for, or something of interest								46.67%	56
4	I often find what I am looking for, or something of interest								27.50%	33
5	I always find what I am looking for, or something of interest								1.67%	2

Statistics	Minimum	1	Mean	3.01	Std. Deviation	0.87	Satisfaction Rate	50.21	answered	120
	Maximum	5	Variance	0.76	Std. Error	0.08				

18. What do you like about using 'Reverse Image Search/Visual Search'?

		Response Percent	Response Total
1	Open-Ended Question	100.00%	71

1	27/01/2021 11:47 AM ID: 157765158	Fairly easy to carry out the search, e.g. drag and drop image on Google
2	27/01/2021 14:34 PM ID: 157786330	you can use an image rather than words
3	28/01/2021 12:26 PM ID: 157865950	Useful to track down who really owns an image. I know some people use it when they're trying to check whether a website selling clothing is legitimate too or whether the images have been taken from elsewhere. Also use it to find out if OUR images are being used without credits elsewhere.
4	28/01/2021 17:04 PM ID: 157899687	It allows us to trace the image and find out if it's original, stolen, widely reproduced and distributed
5	28/01/2021 17:06 PM ID: 157900486	Provides info otherwise impossible to obtain
6	28/01/2021 17:09 PM ID: 157900936	Unexpected knowledge and visual results.
7	28/01/2021 17:12 PM ID: 157900512	little
8	28/01/2021 17:17 PM ID: 157901483	Sometimes textual descriptions are not adequate (or obvious) to help explore atopic/theme/item
9	28/01/2021 17:21 PM ID: 157902391	identifying what something I have photographed is - e.g. a flower, tree or animal
10	28/01/2021 17:45 PM ID: 157904838	It's the most efficient search when I only have an image
11	28/01/2021 18:20 PM ID: 157908049	finding new material, different approach to keyword search
12	28/01/2021 20:03 PM ID: 157916328	I like that I can sometimes find the exact image quickly especially if I know nothing about it.
13	28/01/2021 20:25 PM ID: 157917811	Tracing rights owners. Getting context for an image.
14	29/01/2021 09:10 AM ID: 157937378	Part of risk management process for use of images
15	29/01/2021 09:26 AM ID: 157938971	It's fun to see what google thinks some of my own images are
16	29/01/2021 09:28 AM ID: 157939078	In theory, it's a much more effective way to find something if you have a visual in mind, rather than trying to find keywords

17	29/01/2021 09:54 AM ID: 157941881	Ability to identify the same or similar images, possibly at a higher resolution, and possibly on sites with more comprehensive metadata to help me identify the represented work and its copyright status.
18	29/01/2021 10:05 AM ID: 157942834	Confidence in knowing how 'unique' or otherwise the images in the collections I'm professionally responsible for - especially useful for diligent searches re: orphan works.
19	29/01/2021 10:15 AM ID: 157944419	The ability to more accurately get what I'm looking for.
20	29/01/2021 10:57 AM ID: 157949533	I can find a wide variety of images similar to the idea that I started with, giving me inspiration and helping me develop my original idea
21	29/01/2021 11:58 AM ID: 157957163	In theory, the idea is excellent as it could provide a great deal of information about images which might otherwise be impossible to find.
22	29/01/2021 12:29 PM ID: 157962202	Accurate way of finding an images origin.
23	29/01/2021 13:40 PM ID: 157973854	I've only used it a couple of times but seems like a useful tool for identifying what an image is/who it's of/who took it.
24	29/01/2021 14:19 PM ID: 157979558	I can find images similar to the one I use, it is quick, quite efficient
25	29/01/2021 14:19 PM ID: 157979743	Haven't used it enough to say. Would like to use more to try.
26	29/01/2021 14:21 PM ID: 157980103	Can help identify images I don't know what are
27	29/01/2021 16:07 PM ID: 157996689	Use it to identify plants.
28	29/01/2021 18:07 PM ID: 158011923	For the most part it helps me with the identification of design.
29	30/01/2021 17:04 PM ID: 158082715	I find something completely different to what I was searching for
30	30/01/2021 17:30 PM ID: 158084141	I like getting the best quality image and the best example of that image, as well as information about the image.
31	30/01/2021 18:16 PM ID: 158085814	I most frequently use it to find the specific context of a particular image. quite often I take a quick screenshot on my phone and then forget where the image originated from. It's useful for tracking my steps that way
32	31/01/2021 01:31 AM ID: 158097411	Nothing before in human history can really be said to have a comparable ability.

33	31/01/2021 11:50 AM ID: 158116732	Connectiveness between reality and the web (google lens) Easyness and flexibility to choose a part of the image (Pinterest) A certain number of not expected and surprising, new, results
34	31/01/2021 16:41 PM ID: 158166747	Helps me identify unknown images
35	01/02/2021 09:28 AM ID: 158204004	It feels as though I can sift everything on the Internet- amazing power.
36	01/02/2021 09:51 AM ID: 158206938	Its quite a free way of searching, you don't need to use the correct language or terminology to find what you want. You can explore using a visual language.
37	01/02/2021 09:59 AM ID: 158207771	It can help you find out what the subject of an image is (say, type of plant/flower) when you do not know the name to search
38	01/02/2021 11:37 AM ID: 158221233	Doesn't ask for many informations, you can take any image you've stumbled upon and find out all about it.
39	01/02/2021 12:54 PM ID: 158233697	I haven't used it enough to give a meaningful answer, sorry!
40	01/02/2021 12:55 PM ID: 158233631	It's useful for finding higher resolution images or images without stupid meme text or watermarks.
41	01/02/2021 13:08 PM ID: 158235947	Image orientated search
42	01/02/2021 13:42 PM ID: 158240379	Finding higher resolution image of something
43	02/02/2021 10:18 AM ID: 158319836	I generally use it to find out who owns an image or who has other copies.
44	02/02/2021 10:49 AM ID: 158323111	It's a good idea in principle but I struggle to find what I am looking for a lot of the time
45	02/02/2021 13:25 PM ID: 158344295	When it's successful it is incredibly so - especially for catching out strategic design students submitting others' work.
46	02/02/2021 14:11 PM ID: 158350959	enabling a search when words aren't sufficient to describe what I'm searching for
47	02/02/2021 14:37 PM ID: 158354735	It sometimes enables me to check if a student has deliberately or accidentally copies a piece of work
48	02/02/2021 14:56 PM ID: 158356814	helps to identify things where I have gaps in my knowledge

49	02/02/2021 14:58 PM ID: 158357280	sometimes it is good at throwing up unexpected connections or similiarities.
50	02/02/2021 16:17 PM ID: 158350601	to identify images previously saved for referencing research
51	02/02/2021 17:01 PM ID: 158372807	Flexibility and range of Search
52	03/02/2021 06:52 AM ID: 158400879	It's great for identifying the provenance of an image.
53	03/02/2021 13:09 PM ID: 158434539	Feeling of understanding the mechanics behind how an image populates the internet. Feeling as though you have a more complete picture of how an image has been shared and used.
54	04/02/2021 14:08 PM ID: 158532975	surprises
55	04/02/2021 14:34 PM ID: 158536992	it bring in to play visual literacy, rather than expecting literacy always to be verbal
56	04/02/2021 16:00 PM ID: 158548806	I mainly use for identifying archival images, vintage postcards and similar, some of which are one-off unique items
57	04/02/2021 16:16 PM ID: 158551159	It's easy
58	04/02/2021 16:16 PM ID: 158550197	To find out more information about the image
59	04/02/2021 23:35 PM ID: 158582906	It quickly enables me to find out as much information as I need about an image, such as copyright, location and date the image was made
60	05/02/2021 23:07 PM ID: 158668681	No. Not user friendly
61	06/02/2021 14:46 PM ID: 158695274	Nudging me around an area to find something original
62	08/02/2021 09:21 AM ID: 158821434	It helps you get nearer to what you want to visually - ie without specific knowledge of the things you are looking for.
63	08/02/2021 16:04 PM ID: 158879298	Using Google feels like I have access to a huge set of data to search from, therefore, I have a greater chance of finding what I'm looking for
64	08/02/2021 20:44 PM ID: 158902238	Its just another way to search

65	09/02/2021 12:25 PM ID: 158944581	it usually turns up something of interest	
66	09/02/2021 20:03 PM ID: 158991013	i have been able to find a lot of information about my image, that i dont think i would have gotten otherwise	
67	11/02/2021 10:27 AM ID: 159111630	Filtering results based on copyright and the size of the file	
68	12/02/2021 08:10 AM ID: 159269573	I don't really like it as it has such spotty results. This is why I rarely use it.	
69	15/02/2021 06:42 AM ID: 159448684	Becoming knowledgeable even if you are not	
70	15/02/2021 08:56 AM ID: 159452605	Querying by a visual example both means that you don't have to decompose the image semantically, and the system isn't trying to second-guess what it thinks I find 'similar' (when it does it often isn't, but it can be interesting nonetheless).	
71	15/02/2021 09:36 AM ID: 159455944	Does seem to work well; I find relevant and useful images to solve problems	
		answered	71
		skipped	141

19. How could your experience of 'Reverse Image Search/Visual Search' be improved?

		Response Percent	Response Total
1	Open-Ended Question	100.00%	62
1	27/01/2021 11:47 AM ID: 157765158	Rarely find a match for an identical image unless it's black and white photographs	
2	27/01/2021 14:34 PM ID: 157786330	the results often only match colour or similar pattern, they don't often match subject or content successfully	
3	28/01/2021 12:26 PM ID: 157865950	I tend to forget it exists! I didn't realise there was an integrated version in Google so that might help.	
4	28/01/2021 17:04 PM ID: 157899687	It could be useful to be able to select whether you're looking for identical pics (to trace it for whatever your purposes are) or similar pics (for inspiration)	

5	28/01/2021 17:06 PM ID: 157900486	Ever increasing intelligence
6	28/01/2021 17:09 PM ID: 157900936	Can be overwhelming (though that might just be how I am using it!), would benefit from more advance filters.
7	28/01/2021 17:12 PM ID: 157900512	they should use existing accurate image search algorithms as used in the EU projects such as ARTISTE & SCULPTEUR or the AHRC project FABRIC
8	28/01/2021 17:21 PM ID: 157902391	actually it works pretty well
9	28/01/2021 18:20 PM ID: 157908049	filtering which factors are used to search eg composition, colour, identical search etc. info about how it works
10	28/01/2021 18:42 PM ID: 157910110	better metadata for images online
11	28/01/2021 20:03 PM ID: 157916328	It often seems to find totally unrelated works. A focus on precision would be appreciated or a way to narrow down the filters of what you want to see
12	28/01/2021 20:25 PM ID: 157917811	Better support for mobile
13	29/01/2021 09:28 AM ID: 157939078	I often find that the results don't really match what I'm looking for. I imagine this is a lack of similar images in the depository, and/or perhaps it would be helpful to add some keywords to narrow things down. Perhaps I'm too specific in what I want to find.
14	29/01/2021 09:54 AM ID: 157941881	Matching from trusted sources, such as gallery or archive repositories.
15	29/01/2021 10:05 AM ID: 157942834	Not sure. I mainly use TinEye and the user experience is good. It does sometimes return overwhelming numbers of almost-identical results, though.
16	29/01/2021 10:15 AM ID: 157944419	Ability to add text search to the reverse image search to specify more clearly what I want
17	29/01/2021 10:57 AM ID: 157949533	More information on the source i.e date, author etc.
18	29/01/2021 11:58 AM ID: 157957163	When I tested it, the results were not particularly relevant although it has been some time so I should probably test it again.
19	29/01/2021 12:29 PM ID: 157962202	Can be a bit fiddly to do - especially with a iphone. I always have to google the process before I do it.

20	29/01/2021 13:40 PM ID: 157973854	No idea as I don't think I've used it enough to say.
21	29/01/2021 14:19 PM ID: 157979743	N/a
22	29/01/2021 14:21 PM ID: 157980103	Hard to find it on Google. I think it's supposed to be standard, but I always end up searching for it a while.
23	29/01/2021 16:07 PM ID: 157996689	Accurate input of data from GLAM sector to improve accuracy with links through to catalogues and similar images.
24	29/01/2021 18:07 PM ID: 158011923	I would say the interface of google image could be more intuitive, though I am using a 10 year old computer. ☐
25	30/01/2021 17:04 PM ID: 158082715	Relevance to what I am searching for. Being fine tuned
26	30/01/2021 17:30 PM ID: 158084141	It is often not accurate or returns no matches.
27	30/01/2021 18:16 PM ID: 158085814	It would be great if the screenshot would carry more accessible metadata that would make easier to access the website it was taken from
28	31/01/2021 01:31 AM ID: 158097411	Nothing that I'm sure isn't already under way. Namely that ongoing AI improvement will allow searches to be more intuitive about what's really being searched for/provide more matches to encompass more possibilities of what's really being searched for.
29	31/01/2021 11:50 AM ID: 158116732	A combined search between image search and word search, with a tool to give more or less weight to the image or the word.
30	31/01/2021 16:41 PM ID: 158166747	for my use it works appropriately
31	01/02/2021 09:28 AM ID: 158204004	More content
32	01/02/2021 09:51 AM ID: 158206938	Perhaps by being able to select what type of match I am looking for- shape/style/colour/pattern etc.
33	01/02/2021 09:59 AM ID: 158207771	Maybe having a few filter options so that you can help direct the results to what you want to find
34	01/02/2021 11:37 AM ID: 158221233	Get more precise. Add element of context to have a good result.
35	01/02/2021 12:54 PM ID: 158233697	I haven't used it enough to give a meaningful answer, sorry!

36	01/02/2021 12:55 PM ID: 158233631	It's harder to do it on mobile. You have to open up desktop version of a site. Also, local file navigation on mobile is generally bad. If it never ever ever ever links to Pinterest
37	01/02/2021 13:08 PM ID: 158235947	Better results, identification of people or things in the shot
38	01/02/2021 13:42 PM ID: 158240379	More filters maybe
39	02/02/2021 10:49 AM ID: 158323111	The results usually consist of a handful of images which are quite close to my search and then hundreds upon hundreds of seemingly irrelevant looking images. I would prefer for it to only show me the closest and most relevant results to save me time.
40	02/02/2021 13:25 PM ID: 158344295	Needs to be contextual - seems to match the most easily matched parts of the images (bald white man with checked shirt etc.)
41	02/02/2021 14:11 PM ID: 158350959	often a similar image but of a totally different context is returned so is no use - context awareness by the algorithm would be great
42	02/02/2021 14:37 PM ID: 158354735	it could be more accurate
43	02/02/2021 14:56 PM ID: 158356814	doesn't always give an accurate result - e.g. for plants there can be similar looking plants and the teaching data probably just isn't enough yet in these cases
44	02/02/2021 14:58 PM ID: 158357280	its very hit or miss, it would be good to be able to refine the parameters on which similitarties could be defined
45	02/02/2021 16:17 PM ID: 158350601	I don't know
46	03/02/2021 06:52 AM ID: 158400879	I'm never sure on what criteria it is basing my search on - colour, shape recognition etc. I would use it more if I could prioritise the criteria and see how close a match it was to them. Maybe if I could toggle these too...
47	03/02/2021 13:09 PM ID: 158434539	Ideally, for many reasons, reverse image search would be much more integrated into how images are consumed. I'd like to be able to hover my mouse over any image and see it's history, who has posted it and in what context (say web page header etc), and also see who has posted it in the highest resolution incase i want to use it as my desktop background ;-)
48	04/02/2021 14:08 PM ID: 158532975	using it in a shared project.
49	04/02/2021 14:34 PM ID: 158536992	the idea of cateogrising the sort of similarity being sought is a really interesting one - so that you could specify whether it is compositional, subject oriented, stylistic etc.

50	04/02/2021 16:16 PM ID: 158550197	Practice. Doing it more often.	
51	04/02/2021 23:35 PM ID: 158582906	It can't really as best I can tell at this point	
52	05/02/2021 23:07 PM ID: 158668681	Clearer and straight forward interface. Allow for sorting of museums images vs other.	
53	06/02/2021 14:46 PM ID: 158695274	Get rid of the rounded corners and the symbol on pinterest which gets in the way forever.	
54	08/02/2021 09:21 AM ID: 158821434	Greater sophistication through its interpretation with what I am interested in finding.	
55	08/02/2021 16:04 PM ID: 158879298	More accurate search results - often can't find what I'm looking for	
56	08/02/2021 20:44 PM ID: 158902238	I suppose improvement depends on the amount of (catalogued?) available images available to be searched against	
57	09/02/2021 20:03 PM ID: 158991013	improve finding similar items, instead of returning nothing when it doesn't recognise the image (which Google tends to do)	
58	11/02/2021 10:27 AM ID: 159111630	Icons for reuse shown prominently in results list along with contact details for the page	
59	12/02/2021 08:10 AM ID: 159269573	Better results. Better ability to search by content rather than form or colour or whatever	
60	15/02/2021 06:42 AM ID: 159448684	Better results	
61	15/02/2021 08:56 AM ID: 159452605	More robust retrieval of objects/visual features across images of varying quality (lighting, contrast) and imaging mode. Better integration of visual search with metadata - not necessarily for learning, more for context. More images that can be searched, particularly across collections.	
62	15/02/2021 09:36 AM ID: 159455944	Searching more images and to be able to control decreasing similarity.	
		answered	62
		skipped	150

Annex 3: Case Study Problem Statements and Wireframe 1

Problem statement 1: As a designer when I'm looking for source material for inspiration, I often struggle to frame a useful keyword query to search the graphic collection database. The scale of the collection can also be overwhelming and I don't know where to start. I know what I'll like when I see it.

Potential opportunities:

- Allow users to explore the collections without using keyword search
- Give starting points for users to begin their exploration. These might be:
 - Articulation of visual attributes (e.g. stylistic, colour, subjects represented)
 - Displaying a range of sample imagery that represent a diverse slice through the collection
- Provide multiple pathways between images based on visual attributes
- Allow users to tailor follow-on pathways based on specific attributes
- Allow users to upload, photograph or sketch a visual entry point to search
- Provide additional metadata to develop users vocabulary of the domain

Problem statement 2: As a designer when I'm looking for an iconic image/design for an organisation that I would like to reuse, I struggle to find information around whether there are IP rights associated and who owns those rights so we can request permission.

Potential opportunities:

- Allow users to upload or photograph an image to see if there is a match within the collection
- Bring up similar images which could potentially be by the same 'Creator', Era, Subject matter
 - Attach information around provenance and IP rights
- Provide pathways between images based on visual attributes

Problem statement 3: As a student I sometimes struggle to find imagery for my research. Often I can't find any imagery of the subject at all. When there is it might be low quality or limited to just one view. Ideally I'd like to see different angles or views in different contexts.

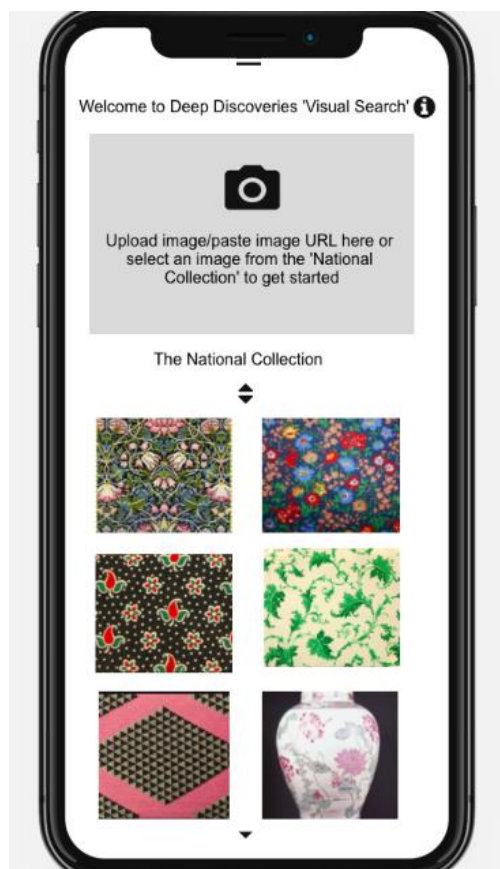
Potential opportunities:

- Focus on the image view as the user's entry point
- Provide pathways to similar images
- Allow users to upload or photograph a visual entry point to search
- Provide IP and institution information, download information

For the purposes of prioritising key elements of this search, the following sketch-up focuses on a 'Deep Discoveries responsive web prototype displayed on mobile' - the Desktop version will have additional features.

Insights so far, from workshop and interviews, have confirmed that 'Provenance' of the visual collection is of interest to users. Ultimately they are trying to find out if they can reuse something or by whom and when it was created i.e. the story behind something. For this, metadata is key and would be folded into the information displayed for an image. So the 'Visual Search' would act as a fast tool to find 'Similar images' and once a user finds something of interest they should be able to view all the relevant metadata for an image so they can get the full picture.

1. Getting started: A concise explanation on what 'Visual search' is and how it works. Here clicking on 'i' would provide the user with more information. Insights have shown that users expect a visual search to present identical and/or visually similar images. A user would start the visual search with an image by uploading from library/taking photo on the fly, pointing camera at an object, pasting in a URL, or choosing from the 'National Collection' to get started.

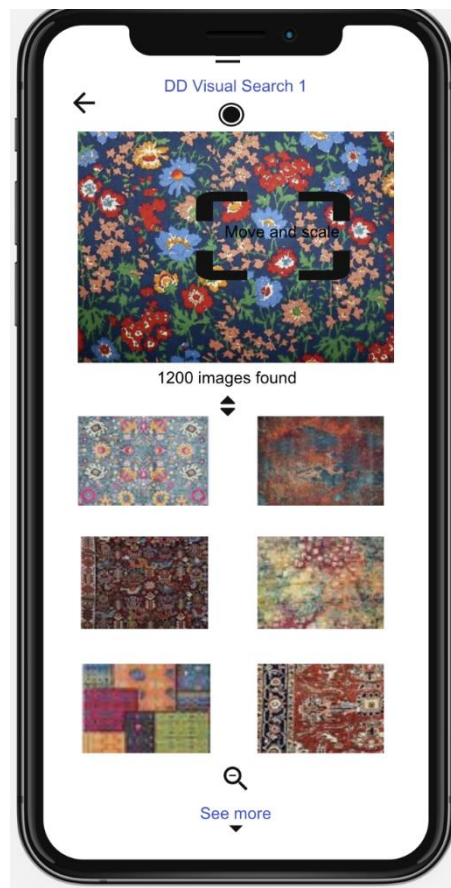


The 'National collection' is vast and a LOT of images to scroll through so some quick filter/sorting options would be offered and this categorization that would best suit users has yet to be decided.

Functionality:

- More information on visual search
- Provide source image
 - Upload
 - Take photo
 - Provide image URL
 - Choose from sample
- Choose source image from National Collection
 - Grid of a subset of imagery from Collection
 - Ability to filter imagery

2. Searching: As a user uploads an image/selects from the collection they are immediately presented with the most similar images at the top.



There is the option to click into a section to crop the image which will then run a new search. The searches are renamed every time the user runs a new search on a part of an image or a new image. These can be saved within the session and revisited.

A user can zoom out of the initial results view above to increase the number of images displayed per page which will of course decrease in size on a mobile. The target icon appears against the 'Source image' i.e. the image from which the search is run.

Whilst it is useful for a user to understand how the search is working, it is also convenient for the user to initially be presented with results without the user having to think about altering the input at this stage.

There might be an option presented at this stage for the user to select and edit facets to modify a search.

Based on discussions we have had so far, insights and how other visual searches work, it makes sense for the backend to run similarity searches based on:

Composition of:

Subject

Colour

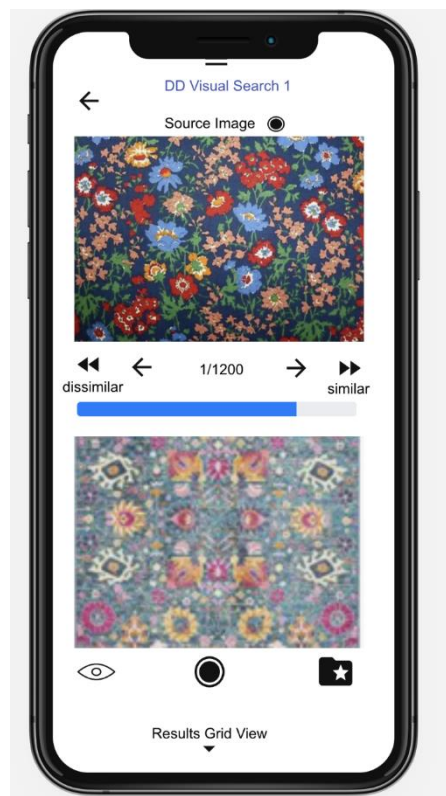
Elements of Art (line, shape, texture, form, space, colour and value)

By default, the search is run on all these in combination and not in isolation to present something fairly useful to the user. Then, maybe the user can isolate these as they wish with additional filter options around Medium (photos, works of art, objects etc.)

Functionality:

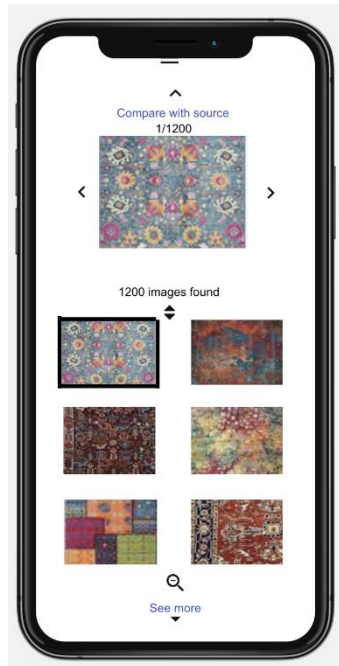
- Search results of visually similar imagery [Q - all combinations or not? Ability to select?]
 - Composition
 - Subject matter [?]
 - Colour
 - Elements of Art
 - Shape
 - Line
 - Texture
 - Form
 - Space
 - Colour
 - value
- Results grid view
 - Ability to change grid view size and number of results
- Crop section of source image to research
 - *Search history (cookie)*
 - *Delete*
 - *Edit*
 - *Re-run*

3. Displaying a result: Selecting an image from the results will then give a comparison view of the result against the 'Source image'

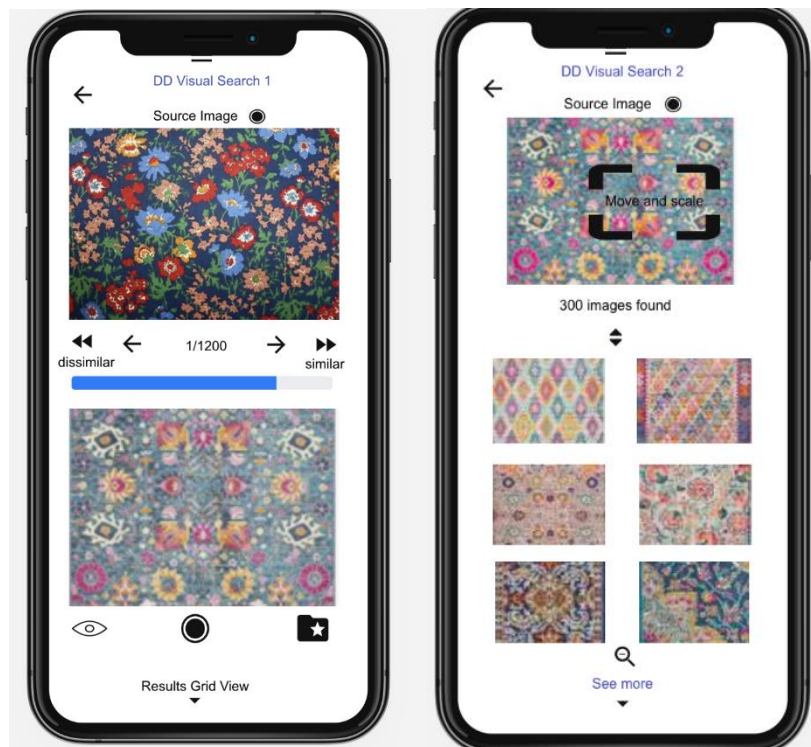


At this stage the user can save images of interest to a folder to review later. The user can scroll through the images from here. Here, as the user clicks on the arrows/forward options they can move through the results set. The bar indicates how close a match the result is to the source image and the user can toggle between the 'Results grid view'

The 'Results grid view' simply shows the results. The user can zoom out to see more tiles on a page of the results and as they select an image at random it shows them a bigger version of the image, They can then return to the view above to compare to the source image.



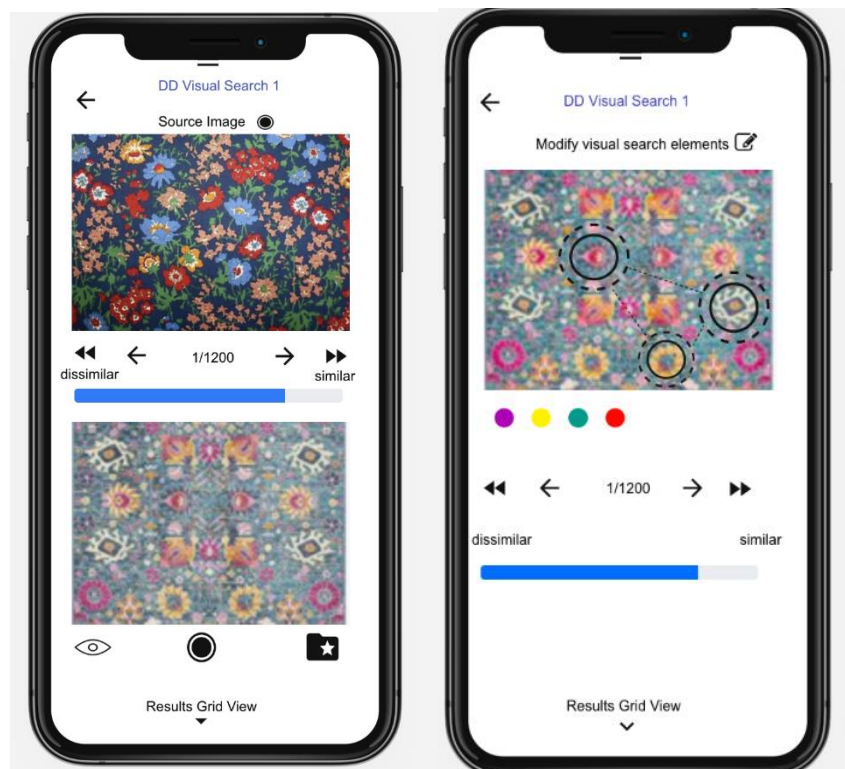
Clicking on the 'Target' icon will change the image to the 'Source image' and a new search is run.



The back arrow consistently allows the user to return to previous view.

Whilst icons can be confusing, they are useful on a mobile. These are suggestions but would need to be introduced to the user in ways they can easily recall the meaning or see a tool tip.

When a user selects the 'Eye' icon under an image will allow a user to inspect the 'Visual elements' the search is based on.



The benefit of this is the user gets to see how the search and similarity was determined.

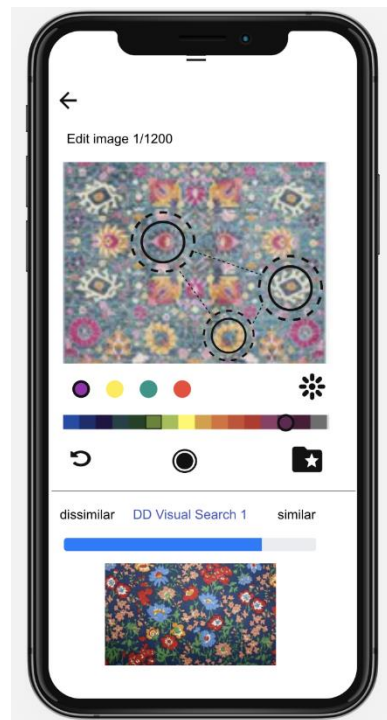
They can flick through results in this mode as well and the bar indicates the match.

Functionality:

- Image source and result comparison [Q]
- Save to view later
- Bar to show level of similarity [?]
- Scroll through imagery [?]
- Back to results button
- Close inspection of image (eye icon)
 - Shows visual criteria [?]

1. Visually altering search criteria on the fly/altering the source image/ working with large sets of results

If they then decide to 'Edit' the image they can modify the 'Visual images'. As they do this they can see how similar or dissimilar the image becomes to the source.



This offers a visual way to filter through results. This highlights the elements of the 'Computer Vision' and can edit some of the simple facets which are feasible without making it too complex. For example, as they modify colour they can see how similar or dissimilar the modified image is compared to the source image. They can then change this to the 'Source' image to run a new search.

To avoid confusion we would stay away from words which can be interpreted differently and are ambiguous such as 'Style', 'Design' & 'Theme' etc.

Functionality:

- Ability edit source image and research
 - Crop
 - Select a colour which has been detected, then alter this from the palette and apply a different colour
 - Additional simple useful edit options to be determined
 - Save modified image to folder
 - Reset

Annex 4: Interface User Case Study Example

Theme

Discovery

Epics

As an art history student, I want to find design inspiration for my next essay.

User Stories

I want to dive straight into the archives without having to spend time searching for a particular category, because I'm not sure what I'm looking for.

I want to discover something interesting about history that I would not usually find through a Google search.

I want to get lost down a rabbit hole to see how parts of history are connected.

If I discover anything interesting, I want to find out more information about it so I can form an essay plan.

Tasks

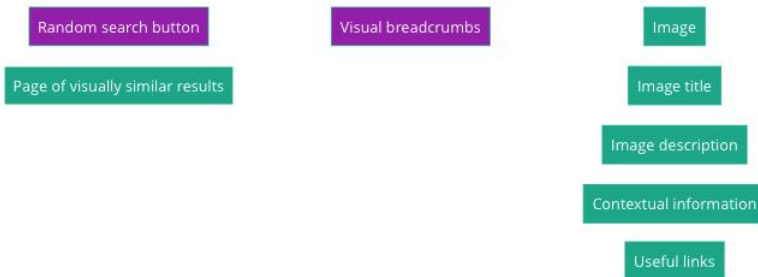
Add a quick search / random search button

Add breadcrumbs to trace the users steps

Display the similarities between images so users can see how they're connected

Add contextual information about each image

Content and Functionality



Annex 5: MOSCOW method for prototype functionality

Must

Should

Could

Won't

Search

- Upload image from file browser [0.5]
- Paste image URL [0]
- Take a photo
- Information about query image e.g. title, creator, collection [0]
- Drag image from search results onto search area [0]
- Choose sample image [0]
- Automatic search for similar images using full query image [0]

Refine Search

- Select areas of interest within the query image [2]
- 'Update Search' button [0]
- Select areas to ignore within the query image [0.5]
- Prioritise selections [0]
- Undo action [1]
- Clear all selections [0]
- Change selection tool size [0]
- Change selection tool colour [0]
- Inverse selection

Results

- Display results in 2D grid, in strength-of-match order [4]
- Display results in original proportions
- Toggle between image view and similarity mask using a switch [0.5]
- Toggle between image view and similarity mask on hover over image [0]
- Select image as new query image [0]
- Select image as new query image – with existing similarity mask
- Select image as new query image – without a similarity mask
- Select images of interest [1]
- Select areas of an image of interest [0]
- Select images to ignore
- Select areas of an image to ignore
- Update search button [0]
- View image information e.g. title, creator, collection [0.5]
- Scale image thumbnails using a slider [1]
- Bookmark image [1]
- Share image [1?]
- Download image

History

- Create cookie to record search history & bookmarks [4]
- Bookmark history images
- History of query images
- History of query images with selection mask
- Delete images from history
- History of selections of similar images from results

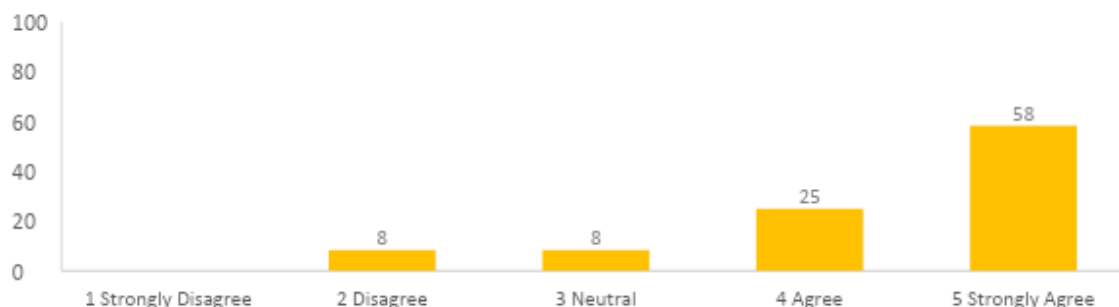
- Requirement for a user login or account

Bookmarks

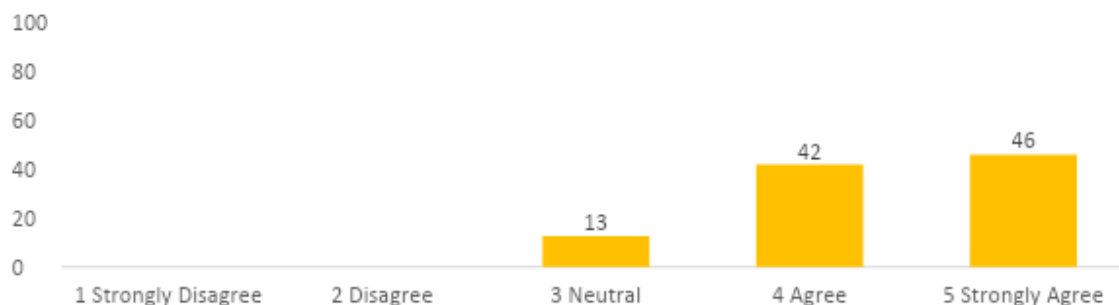
- Delete bookmarked images [0.5]
- Add bookmarked images to a collection
- Compare bookmarked images side-by-side

Annex 6: Unmoderated Testing Results

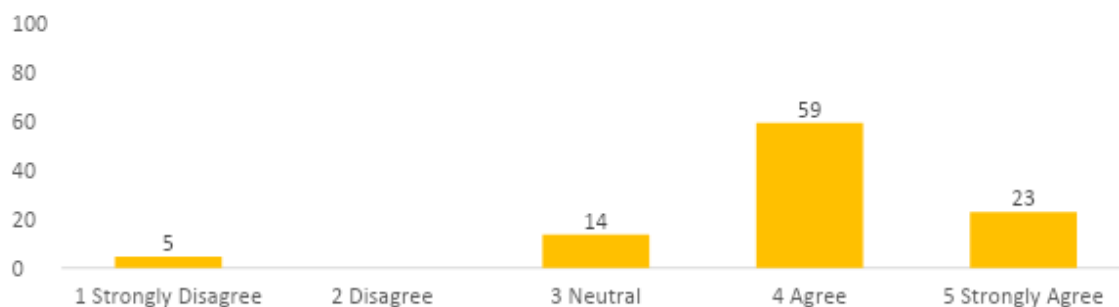
Being able to search using an image, rather than a keyword, is something I would find useful when exploring gallery, museum, or archival collections online.



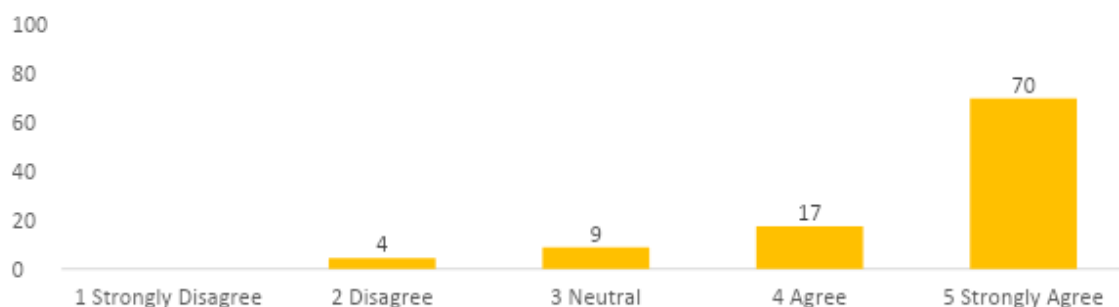
I understand that the heat maps indicate the areas of likeness between my search image and the result/returned images, as perceived/calculated by the AI.



Understanding what the AI finds similar helps me redirect my search to areas in my original image that are more important to me.



Being able to select a specific area of interest in my search image, using the Detailed Search function, is helpful



Please add any other comments you may have about this section

‘Whilst I can see that this is potentially a powerful tool, I found the limited interaction and ability to explore made it difficult to feel comfortable answering most questions with anything other than neutral’

‘The tool did not allow me select the area of the image I was interested in. It defaulted twice to a specific area I hadn't selected. The images it generated in the earlier stage did not seem to be usefully similar. ‘

‘This feels like a useful tool to enable searches to be conducted without needing to worry about terminology which can often be classified in many different ways, therefore making the process more user friendly. ‘

‘It would also be useful and interesting to be able to highlight a layout or shape of a composition rather than just isolate motifs - ie. if the image was a landscape then it would be useful to be able to search the database for all images that have a low horizon viewpoint’

‘it appears to be looking for spatial organisation which may be relevant but what about other visual effects - line quality, media, texture?’

‘still quite difficult to highlight specific areas’

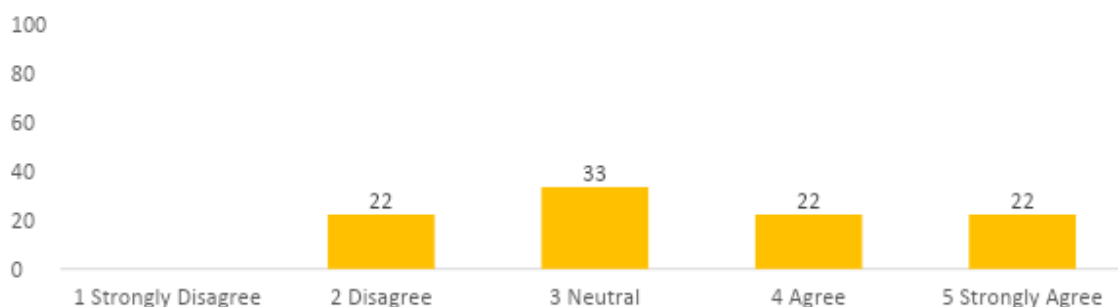
‘I found that the idea of using AI to search useful, although the action of it was clunky. I would need to use it a couple of times to feel comfortable using it.’

‘How to define detail is missing here’

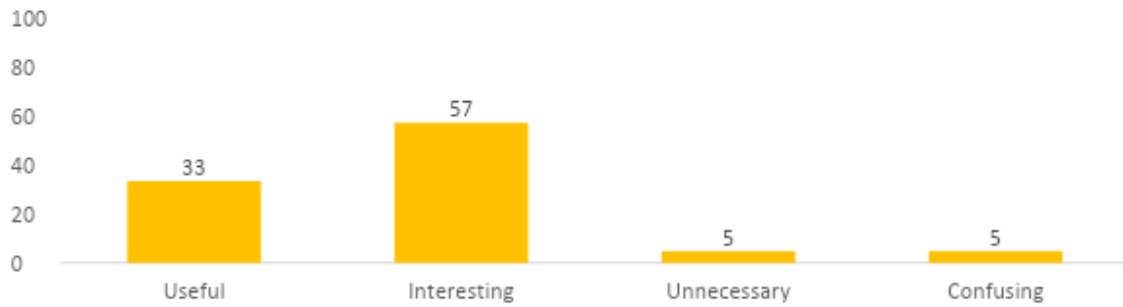
‘This is an exciting and interesting technology that will completely change the way in which I will be able to interact with visual collections. I can't wait for it to be applied to larger data sets. Not only is it useful for research, but the interface is just fun and entertaining. It makes you want to just play with it for a long time. I can imagine that this is even more the case when that are more images in the system. ‘

‘The selection function is potentially very interesting.’

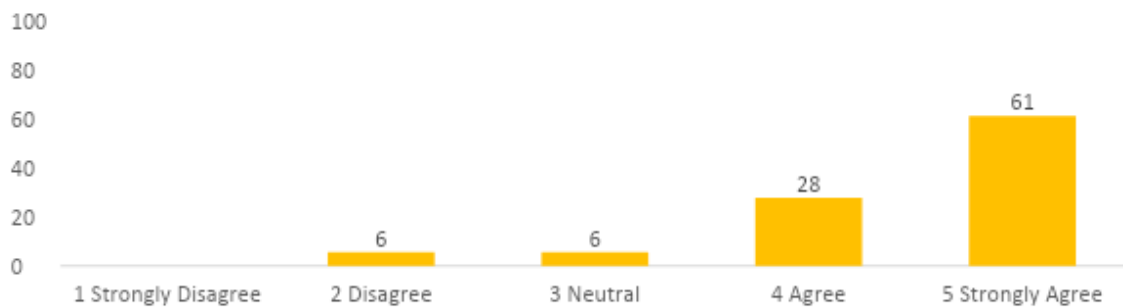
It was clear that I was adding images to the search, rather than starting a new search.



I find the ability to search and discover collections online using multiple images



The ability to specify which parts of each image in the 'search set' are relevant/of interest to me is useful



How might the ability to 'tell' the AI which areas are more relevant/interesting, on multiple result images through the Detail Search function, be useful to you?

'The AI didn't appear to be able to 'tell' very much - hard to see how it is matching something which is an image - i.e. a fish, tone, colour i.e. black outline or if as it appears it was relating to scaled section? The ability to control the tools was negligible. '

'It would be useful in relation to identifying particular motifs and seeing trends and representations of this through different items e.g. are particular motifs appearing in textiles from different cultures/countries of origin, and thereby exploring design influences.'

'Looking for more examples of certain figures that come up in drawings'

'very'

'it would allow me to look to less obvious collections - eg. natural history, history of medicine collections as part of my research into say, pattern design. Also, images educate me on how different visual elements have been used together in the past - eg. checks and bows, stripes and flowers, so it would be useful to be able to search across sources for examples of these elements together and apart.'

'ability to search for specific shapes'

'I can be more specific about what I am looking for, in multiple images'

'On maps, features are very small and finding similar ones requires limiting the search area.'

'When trying to find representations of specific objects/features'

'Might make it more relevant - but when I'm working visually, anything getting in the way is annoying as it breaks my flow. Like someone talking about something irrelevant during a film.'

'see repetitive patters across time'

'To narrow down results'

'This will be extremely useful. Being able to pick out aspects of an image that are relevant will make visual research exponentially easier and more interesting. '

'Being able to crop photographs from their archival mounts, for example.'

'For use in creating new textiles and designs by selecting techniques or approaches in one piece of work then using that as a springboard to find other pieces that might also inspire me '

'I can be more specific with my research'

If you could carry out visual searches across all collections online (museums, archives, galleries and libraries across the UK), might this tool be helpful to you and if so how?

Yes – 17 (100%)

No – 0 and 0

If you say this tool could be useful please say how?

'It would be useful if the potential were clearer how the association was being conducted. I work in museums and have come from a visual art background and so I am used to reading images - visually - first so the tool interests me...it appeared to be a test to find relationships with paisley ...I'm curious how the tool would function across more differentiated materials. I think this was paper design, wallpaper, textiles.'

'Textiles are visual items, it can be difficult to describe design features in a simple and universal way. By searching on design elements, this process should in theory be made much quicker and easier to return the desired results. We would find this useful as a museum in terms of connecting with other collection items that are similar to items we have ourselves. We also feel that this would be a useful tool for students and researchers in exploring collections and focusing in on exactly what they are looking for. '

'compare similar items across collections'

'it would save me having to visit each institution's online catalogue separately and create separate databases of origin and copyright information - or even worse, have to print those images off.'

'Searching the contents of digitized collections for specific shapes or types of things represented on documents (compass rose examples, the representation of specific scientific tools in documents).'

'I work with visuals rather than assembling records - I am always doing visual searches. Keywords are different.'

'see fashion/culture maintained across time'

'The ability to programatically recognise stylistic motifs or iconographic symbols would be helpful in 'curating' sets of images or testing research questions.'

'I would discover things in collections I did not know were there'