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*Voir l'odeur. "Sourcer" l'imagerie olfactive à l'aide de l'intelligence artificielle*

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# Seeing Smell: Sourcing Olfactory Imagery Using Artificial Intelligence

*Voir l'odeur. "Sourcer" l'imagerie olfactive à l'aide de l'intelligence artificielle*

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- 1 Of all the senses to analyse through imagery, smell may be one of the most challenging. Its sheer invisibility makes it difficult to verify in visual terms. However potent an ineffable scent may be, it is dependent on the image's visible, material expression to picture it. Even when smells are identifiable in imagery, the historical devaluation of this "lower sense" has led to a tendency to exclude it from the documentation of artworks<sup>1</sup>. Researching the sense of smell in imagery also diverges from iconographic conventions: odours in imagery tend to manifest in different ways than with other visual tropes, where they can be seen criss-crossing through established genres and borders; a phenomenon that will be discussed in more depth below. However, art historians have started to grapple with the unruly subject of smell's manifestation in art, by exploring allusions to the olfactory through a range of olfactory cues.
- 2 To provide some examples, spanning time period and place: Pachomius (Matthew J.) Meade explored the depiction of smell in 15<sup>th</sup>-century religious Netherlandish paintings<sup>2</sup>, Claire Dobbin and Leslee Katrina Michelsen mapped the olfactory in the art of the greater Middle East<sup>3</sup>, while Nina Ergin covered Ottoman art<sup>4</sup>. The olfactory in Renaissance art has been François Quiviger's area of focus<sup>5</sup>. The olfactory in 17<sup>th</sup>-century Dutch art has received considerable attention with the research undertaken

for the 2021 exhibition *Fleeting – Scents in Colour* at the Mauritshuis, The Hague, which incorporated the PhD research conducted by this article’s co-author Lizzie Marx on visualising, perceiving, and experiencing smell in Dutch art<sup>6</sup>. In the modern period, this volume’s co-editor Érika Wicky has paid special attention to scent in 19<sup>th</sup>-century France<sup>7</sup>, and Christina Bradstreet on smell in 19<sup>th</sup>- and 20<sup>th</sup>-century Western art and aesthetics<sup>8</sup>. In avant-garde art, the olfactory strayed from imagery, and became a medium of the art itself. Caro Verbeek has studied how odours were used by the Futurists in their artistic practice<sup>9</sup>, and extensive scholarship has since covered the synaesthetic interplay between the visual arts and smell, and works that incorporate scents, known as olfactory art<sup>10</sup>.

- 3 Such research illustrates the potential for exploring the olfactory in imagery. It comes at an auspicious moment as heritage institutions have started to mass-digitise their collections. A wealth of imagery that might allude to the sensory is becoming more accessible and available for analysis. However, this poses a new question: can digital collections help us trace smell within art history?
- 4 This article describes the way in which the Horizon 2020 Odeuropa project is training artificial intelligence to source olfactory imagery in digital art collections. Odeuropa uses computer science techniques to identify and trace references to smell in Europe between 1600 and 1920 in text and image collections. The time period covers a transformative shift in Europe’s olfactory history, where olfactory products imported through colonial exploits were traded and consumed, the European smellscape was irrevocably changed by the forces of the Industrial Revolution, and scientific developments advanced the conception of the very workings of odours and olfaction<sup>11</sup>. The project largely focuses on olfactory imagery in paintings, prints, and drawings, however as the technology advances, it may be able to identify references to smell in a broader visual culture, such as advertisements and book illustrations. The “Semantic Web” strand of the project prepares a semantic model for representing the information in a machine-readable knowledge graph, and the “Storylines” strand draws together and presents major concepts and theories in the history and heritage of smell from the knowledge graph. The “Olfactory Heritage Science” strand documents smell as an expression of material reality, and, together with the “Impact” strand, promotes the project’s outputs and methods through engaging with its network, including scholars, heritage and museum professionals, and digital humanities specialists, as well as European cultural heritage policy-makers<sup>12</sup>.
- 5 In Part One of this article, we combine heritage science and art history approaches to review how museums and archives have struggled both to document and classify olfactory imagery and the olfactory itself. While museum collections often do not refer to the olfactory in their metadata, archives of scents, as we will argue, can offer inspiration on how to approach the sensory in heritage documentation. In the wake of initiatives to decolonise collections by reuniting pieces with their sensory context, we see possibilities, or even a necessity, to enrich material and digital collections with olfactory information.
- 6 In Part Two, we explain the technology and techniques that the Odeuropa project is developing to find olfactory imagery in digital collections. We explain how we employ computer vision to mine olfactory images in collections databases, also describing the technical and methodological challenges we have worked through, and the questions they raise about sourcing pictures of sensory experiences with artificial intelligence.

Part Three presents a case study, describing the implementation of an automatic recognition system for one of the olfactory objects which has been identified as smell-relevant: perfumed gloves.

- 7 We will conclude by suggesting the ways in which the mined imagery can be implemented for research and heritage projects. By broadening access to olfactory imagery, this article argues that it will be possible to gather more insight into what it means to see smell in early modernity and modernity, and lay the groundwork for further initiatives that use technology to picture sensory experiences.

## Part One: Archiving the olfactory

### Odorous artworks: The materiality of scents

- 8 Before we discuss the representation of smell in images, let us first think about smell as an expression of materiality in our heritage institutions and collections. Although museums have been described as “anosmic cubes” that prioritise the visual over the other senses, smells are part of their buildings and collections<sup>13</sup>. There are some examples of archives or galleries specifically dedicated to smell. Sissel Toolas’ archive of odours collected from sites across the globe, Mandy Aftel’s archive of perfume ingredients, or the Osmothèque’s extensive archive of perfume history and heritage provide good examples<sup>14</sup>. However, the archival repositories, museums, and collections mostly used by art historians and other humanities scholars have tended to ignore smells, or have not included them in their metadata. This means that smell still resists archival cataloguing in the 21<sup>st</sup> century. This is also illustrated by the cataloguing of artworks that have included smell alongside the visual. The 2007 multi-media installation *La Bouche du Roi* by Romuald Hazoumé which appeared at the British Museum as part of the 200<sup>th</sup> anniversary of the abolition of slavery combined video, sound, and petrol can “masks”, arranged in the shape of the Brookes slave ship made famous by abolitionists. The installation also mixed the smells of tobacco, spices, urine, and faeces, conveying the filth which lay at the roots of the lucre and luxury generated by slavery. However, in the British Museum catalogue it is very difficult to find any references to the smells associated with the installation, while most other elements have been archived<sup>15</sup>.
- 9 The digitization of archives and collections has caused us to rethink this lacuna in our documentation. The risk of marginalising the less easily digitised material and sensory properties of collections has encouraged archival science scholars to reconsider the role of smell: what happens when original images or objects are lost or scholars only engage with the digitised versions<sup>16</sup>? André Malraux’s “museum without walls” also threatens to be a museum without scent<sup>17</sup>. The last few years or so have therefore seen attempts to re-introduce smell back into the archival metadata associated with objects, images, and texts. Scholars have pointed out that many possibilities – including technologies such as gas chromatography mass spectrometry – exist for analysing, digitising, and re-materializing scents from historical texts, objects, and images that already exist in archives<sup>18</sup>. Projects are underway that seek to create archives of chemical smell data linked to historical objects or artworks<sup>19</sup>. One motivation for re-entering smell (and other sensory impressions) into catalogue data has been the desire to decolonise collections that contain indigenous objects<sup>20</sup>. These objects have often

been divorced from their original contexts of use. By engaging in object-handling, interviews, and ethnographies with the original owners of these objects, archaeologists (for example) have sought to then record the smells of objects in their catalogue metadata<sup>21</sup>. For instance, when a model dog sled was catalogued at the Native Canadian Centre of Toronto in 2014, the entry incorporated the experiences from Cree and Anishinaabe indigenous seniors who discussed the piece together. The cataloguing system was updated with new fields, such as “Use in Handling Session”, where the participants’ sensorial impressions and associations could be recorded. The session elicited for the participants the scents of pine, tarmac, cedar, and porridge, which could all be accounted for within the catalogue<sup>22</sup>.

- 10 Digitization and decolonisation are just two of the developments urging us to integrate smells into museum and archival catalogues. However, these examples focus on the handling of objects rather than the reading of images; surviving materialities rather than olfactory symbolism. We can, to some extent, analyse the smells of historic objects using methods from analytical chemistry<sup>23</sup> or re-integrate olfactory descriptions of their use from the cultures for which they carry meaning: novel methodology is being developed for this purpose by olfactory heritage scientists<sup>24</sup>. Images offer a very different set of problems. How can we locate, catalogue, and then search for olfactory references that are visual and representational rather than chemical or embodied? These questions involve seeing smell, working at the intersection of sight and olfaction, rather than re-sniffing collections through machine or human noses.

### Enriching Iconclass to overcome anosmia in digital art collections

- 11 Heritage institutions have invested heavily in digitising their collections, providing a wealth of data for humans and machines to explore. However, the metadata of these digital collections, including image classification systems, prioritise the visual aspects of imagery over more sensory ones. They reflect long established norms which often leave the sensory in imagery overlooked. To map out some of the gaps of olfactory informative metadata within digital collections, we will focus on Iconclass, a classification system used by museums and libraries to record the content of images<sup>25</sup>. It allows for an extensive range of things depicted in imagery to be codified with designated concepts<sup>26</sup>. Since this multi-lingual classification and labelling system is widely used in digital heritage collections (such as Rijksstudio, Europeana, etc.), its lack of olfactory labels and metadata may be one of the causes for the current “anosmia” in art history<sup>27</sup>.
- 12 Iconclass divides the concepts into ten, hierarchically ordered subdivisions. As of 2021, it contains over 28 000 concepts and 14 000 keywords, offering a wealth of digital information to search from. When exploring the database, we noticed different gaps in olfactory related concepts, keywords, and classifications. Firstly, many concepts which relate to olfactory imagery lack sensory-related information, such as the naming of specific odours. An example of this is Iconclass code 12A3121 or *The altar of burnt offering in Tabernacle ~ Jewish religion* (Exodus 25-31, 35-40). Although the label includes olfactory information by indicating a “burnt offering”, the concept lacks specific information such as the materials that made up the burnt offering itself, which are galbanum, frankincense, and onycha (Exodus 30: 34). Secondly, we observed that there are olfactory-related narratives and vocabularies that do not currently have a concept

within the database. For example, depictions of anointing, or the ceremonial act of smearing a scented substance (or perfume) on someone to demonstrate their holiness. An example of this is a scene from the Bible where Mary of Magdalene kneels before Christ and smears precious spikenard oil on his feet (John 12). The Iconclass concept connected to this scene, however, does not mention spikenard – a precious material which comes from the root of a flower which is often linked to the divine. Instead, code 73D132 only mentions that Christ’s feet are anointed by Mary (Magdalene), which omits two key olfactory vocabularies of the story: “spikenard” and “anointing oil”<sup>28</sup>. Here, the addition of olfactory information can enhance the knowledge about the history of smell and olfactory practices, providing new ways to engage with the digital and physical collection. This, thirdly, brings us to the possible expansion of Iconclass with new concepts that also capture olfactory gestures (sniffing, pinching the nose), and fragrant and malodorous places (dung heaps, volcano pits, flower gardens), thereby making their olfactory qualities explicit. The addition of olfactory attributes to the candidate concept of 31A33 *smell, smelling (one of the five senses)* would draw together odorants such as frankincense, tobacco, sulphur, or perfume, so that researchers can follow smell trails through images and genres. This brings us to our last point: Iconclass also provides the possibility to navigate through various interconnections between keywords and concepts. However, in the case of the codes which relate to the five senses, 31A33 *smell, smelling (one of the five senses)* lists fewer keywords than 31A31 *sight, looking (one of the five senses)*. By adding connections, users could be enabled to forge new links between different scenes and genres.

- 13 At this moment, the Iconclass team and the Odeuropa project are collaborating to redevelop the platform to be more inclusive of the olfactory<sup>29</sup>. The enrichment of Iconclass will be an important step to help digital heritage collections take a sensory turn, providing new pathways for visitor engagement and interaction with the past<sup>30</sup>.

## Part Two: Sourcing olfactory imagery using artificial intelligence

- 14 Enriching the Iconclass system suggests one way in which the olfactory, fundamentally an invisible entity, can be inferred and accounted for within digital heritage collections. The Odeuropa project is pursuing this by using artificial intelligence to explore further allusions to smell within digital archives. The application of machine learning techniques can be subsumed under the field of computer vision<sup>31</sup>. Common tasks of computer vision algorithms are classification, object detection, and segmentation. These tasks differ in the scope they take into account. In classification, the algorithms look at the whole image and assign a category according to what is being depicted. Object detection works on smaller regions of the image and entails the localization of possible objects and their classification. In segmentation, each image pixel is considered separately and can be assigned to a category.
- 15 In the Odeuropa project, we use computer vision to analyse large amounts of visual historical data to find traces of past smells. Using object detection informs us not only about what smell-relevant objects are depicted on artworks but also about their location in the image, and about the spatial relationships between the recognised objects. In a second step, we aim to use the extracted information about objects and

their positions to make assumptions about more complex smell references such as iconographic allusions, smell-related gestures, or fragrant places.

### Categorising olfactory depictions for computer vision

- 16 In his article on smell and taste in art, Christian Dieter Sauer identified the representation of the olfactory and gustatory in three different phenomena: 1) *Iconographic patterns*, as seen in image traditions where narratives allude to the olfactory or gustatory; 2) *Allegories and personifications*, where the Sense of Smell and Taste constitute the Five Senses, and where personifications have olfactory attributes, such as the roses of Venus; and 3) *Still lifes*, where the objects on display are so convincingly rendered that the viewer is compelled to imagine their smells and tastes.<sup>32</sup> Odeuropa has adopted these three categories as part of its image mining. However, we have also uncovered further examples of olfactory depictions, which lead us to the identification of four types of visual smell references:

#### Olfactory objects

- 17 For Odeuropa, *Olfactory objects* include odorous substances such as plants and foodstuffs, and olfactory artefacts such as tobacco pipes (fig. 1)<sup>33</sup>, perfume bottles, and pomanders (scented jewellery)<sup>34</sup>. Sauer's *Still lifes* category connects most to this category, in addition to numerous smell emitting objects in genre scenes, history paintings, etc. For instance, still lifes as well as genre scenes represent smoking requisites and habits, and by searching for pipes through image archives, computer vision can gather imagery relating to smoking and its development over the centuries. Proxy objects related to smell are also among this category. For instance, flies do not give off a perceptible smell, however they are often indicators of scent, as they can be found in images congregating near fragranced or putrefying matter. Their inclusion in an image can be read as a visual reiteration of an olfactory presence.

Fig. 1



Pieter van Anraadt, *Still Life with Earthenware Jug and Clay Pipes*, 1658, oil on canvas, 58.8x67 cm The Hague, Mauritshuis.

### Olfactory iconographies

- 18 *Olfactory iconographies* include two of the categories listed by Sauer: *Allegories/Personifications* and *Narratives*. We aim to capture smell-related iconographies where olfactory narratives and symbolisms (which are often derived from textual sources), correspond to the imagery. As in the story of the Raising of Lazarus, the Bible recounts that as Lazarus had been dead already for four days, “by this time he stinketh”<sup>35</sup>. In depictions, bystanders can be seen pinching their noses (fig. 2)<sup>36</sup>.



Fig. 2



Giovanni Francesco Barbieri, known as Il Guercino, *The Raising of Lazarus*, 1600/1625, oil on canvas, 201 x 233 cm

Paris, Musée du Louvre, photo RMN-Grand Palais (musée du Louvre) / Gérard Blot

Allegories of the Sense of Smell are also included in this category, where Smell may be represented by personifications with their objects and animal attributes, or in scenes of daily life, where olfactory objects and gestures can also be referenced (fig. 3)<sup>37</sup>.

Fig. 3

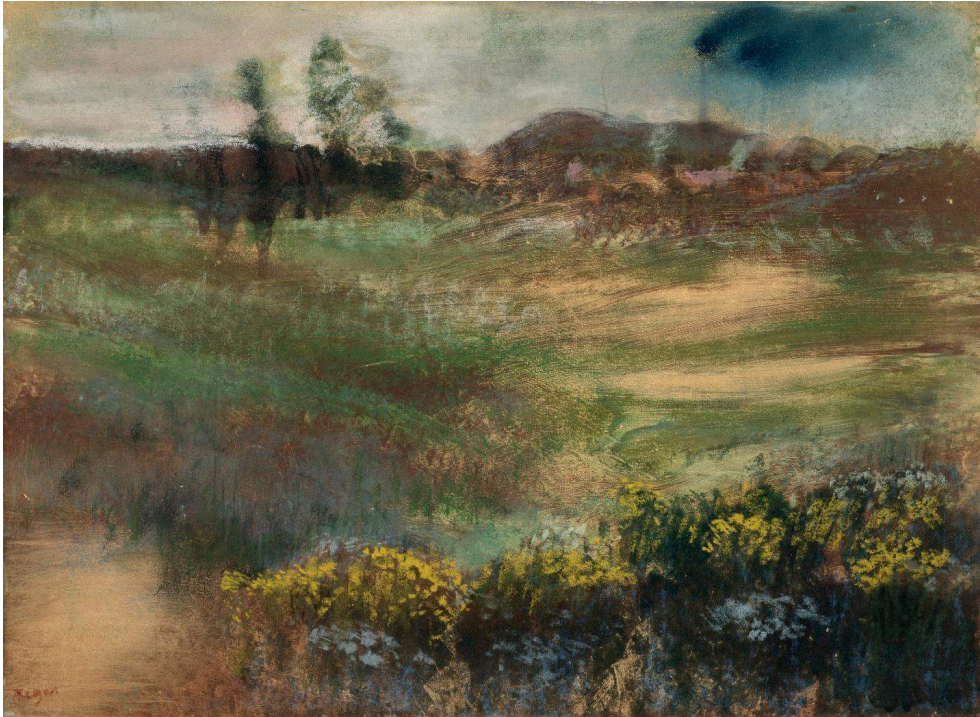


Philippe Mercier, *The Sense of Smell*, 1744-1747, oil on canvas, 132.1 x 153.7 cm  
New Haven, Yale Center for British Art, Paul Mellon Collection

### Fragrant places

- 19 The category of *Fragrant places* includes built environments such as farms, factories and churches, and natural spaces such as forests and flower fields. The Odeuropa project covers a period (1600-1920) where the European olfactory landscape was rapidly and drastically transformed. For instance, the increasing use of fossil fuels during the Industrial Revolution is evidenced by the smokestacks looming in the background of Edgar Degas' work (fig. 4)<sup>38</sup>. Sourcing various environments can inform the olfactory qualities of places and help to analyse how they were represented.

Fig. 4

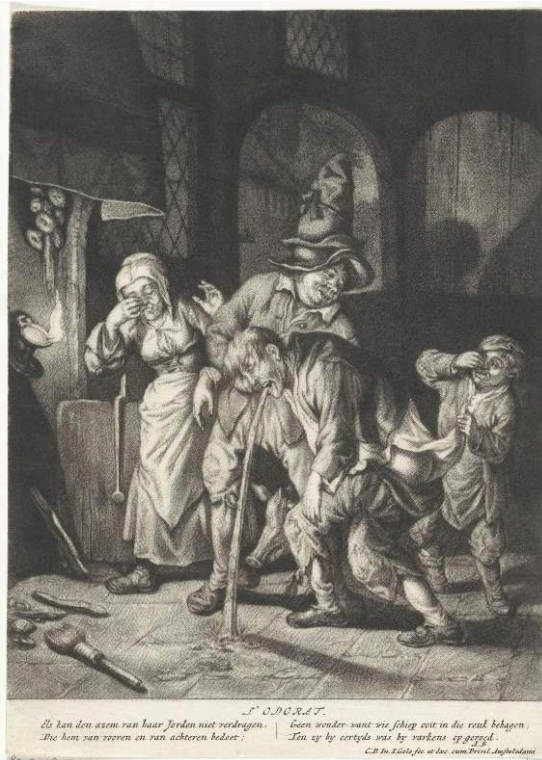


Edgar Degas, *Landscape with Smokestacks*, 1890-1893, pastel over monotype, on wove paper, 317 x 416 mm, purchased from the collection of Friedrich and Louise Gutmann, and gift of Daniel C. Searle. Chicago, The Art Institute of Chicago

### Olfactory gestures

- 20 *Olfactory gestures* include holding the nose, making a facial expression in reaction to a smell, bringing odorants to the nose or consuming an odorous substance, such as taking snuff, as well as actions that produce a smell, such as urinating or vomiting (fig. 5)<sup>39</sup>. Olfactory gestures are not limited to human noses. Dogs, for instance, are often an attribute of the allegorical Sense of Smell, as are vultures. The mined imagery that expresses emphatic reactions to odorants by (non-)humans can shed new light on the common sentiments concerning odours in Europe.

Fig. 5



Jacob Gole, after Cornelis Dusart, 1670-1724, mezzotint and engraving, 255 x 184 mm  
Amsterdam, Rijksmuseum

## Challenges for computer vision

- 21 A major challenge that we face in the recognition of these four categories is the overall mismatch between historical imagery and the modern photographs on which computer vision algorithms are usually trained. The differences urge computer vision techniques to take into account different styles of representation<sup>40</sup>. With realistic imagery, such as the bouquets of 17<sup>th</sup>-century Dutch still lifes, the mismatch between historic paintings and modern computer vision datasets is comparatively small. In these cases many computer vision algorithms can directly be applied without much modification: the close observation of the flowers are integral to their depictions<sup>41</sup>. However, as the level of abstraction increases, off-the-shelf algorithms struggle more and more to transfer their vision capabilities trained on photographic material.
- 22 This is exemplified by artworks that strongly deviate from a naturalistic representation, such as mediaeval iconography or more recent works of art (1860s onwards). A painting by Claude Monet of the steam trains' smoke that fills up the Gare St-Lazare is evidently rich in olfactory information (fig. 6)<sup>42</sup>. However the rough, impressionist brushstrokes, which are such a defining feature of the painting, are also the obstacle that makes it challenging for computer vision to detect the olfactory cues.

Fig. 6



Claude Monet, *Arrival of the Normandy Train, Gare Saint-Lazare*, 1877, oil on canvas, 60.3 x 80.2 cm  
Mr. and Mrs. Martin A. Ryerson Collection, Chicago, The Art Institute of Chicago

- 23 Recent developments combining textual understanding and visual feature extraction have demonstrated the potential to overcome stylistic differences and artistic abstraction to a large extent<sup>43</sup>. While they overcome some of the formality restrictions of more traditional object detection methods, current studies have revealed that, as a result of their training procedure, these models adapt the biases of modern visual internet culture<sup>44</sup>. Accordingly, they are very well suited for established research questions, but fail to capture olfactory semantics of paintings, which are not present in the data the models have been trained on<sup>45</sup>.
- 24 Image recognition then needs to be enhanced with a preliminary domain adaptation training step that enables the algorithms to learn properties about the domain on which they are applied<sup>46</sup>. One method of domain adaptation is style transfer, where labeled photographic datasets are artificially transferred to the style of the artistic target domain before training a recognition system, e.g. by mimicking the style of a specific artist or period<sup>47</sup>. Self-supervision is another domain adaptation technique that leverages large-scale, unlabeled datasets to teach the model properties about the target domain without having to go through the costly process of manually creating annotations<sup>48</sup>.
- 25 In order to increase the capabilities of our recognition system, we are planning to use a combination of these approaches. Furthermore, we will use a variety of different genres and styles in our training. The early modern period's thriving print culture approaches the olfactory quite differently from paintings. Graphic satires, for instance, can refer to odours through visual representations, or occasionally through the accompanying text. The linear and typically monochromatic qualities of the image also differ from painted

brushstrokes<sup>49</sup>. By starting from naturalistic paintings and then gradually increasing the level of abstraction and variety in multiple iterations, we hope to capture more and more smell references from a broader visual culture, possibly enabling us to analyse not only paintings and some prints and drawings, but also graphic satires, book illustrations, and more<sup>50</sup>.

- 26 The four categories of objects, iconographies, places, and gestures also hold their own particular challenges when dealing with computer vision. In the following section, we outline some of the most compelling examples.

## Challenges for olfactory objects

- 27 When looking for smell references in artworks, one straightforward approach is to try recognising smell sources, which are, in many cases, represented as objects. In collaboration with chemists, art historians, and smell researchers we assembled a list of objects that carry a strong smell (and are in fact described as odorous in historical texts), and might be depicted in historical artworks, such as flowers, tobacco, beer, resins, and cadavers.
- 28 Apart from smell sources, objects can also have a more indirect connection to smell, for example vessels that contain odorous substances such as perfume bottles, apothecary cabinets, and pomanders. We also capture proxy-objects that co-occur with olfactory objects to highlight their smell qualities, such as flies or other insects on fruit and flowers, pointing to the smell of decay, and metaphors for the sense of smell, such as dogs. Considering all these kinds of smell-related objects, we compiled a list of more than 600 candidate objects that would be valuable to detect in images<sup>51</sup>. Since the large number of object categories, as well as the peculiarity of some of these objects, pose too many challenges for automatic recognition, we currently restrict the detection to a set of 87 categories, which will be extended further in the course of the project<sup>52</sup>.
- 29 One of the challenges computer vision for art history faces is the tension between the necessity for extensive data sets (which requires the collection of images spanning different centuries) and concept drifts. Not only do the artistic genres and styles change over time but the olfactory qualities of certain depicted objects do as well. An effective concept drift in olfactory terms occurs when the objects appear to be the same, but they smell quite different. In the case of leather gloves, after the mid-19<sup>th</sup> century, the use of chromium salts in leather tanning rid the skin of its residual scent of urine and manure. Gloves were also made of other materials, such as wool and silk. Computer vision will be mining images of gloves across the timeframe that Odeuropa has set, however in an olfactory sense, an image of gloves from the 17<sup>th</sup> century has more in common with a depiction of a used bedpan from the 19<sup>th</sup> century, than a pair of 19<sup>th</sup>-century gloves.
- 30 Not all of the objects that computer vision mines will ostensibly be related to the olfactory. Flies, for instance, were introduced in the “Objects” category as a proxy object of olfactory presence. A clear example is a painting on copper by the Dutch artist Ambrosius Bosschaert the Younger (fig. 7)<sup>53</sup>. A frog lies prone on its back, while three flies clamber near its body, and a fourth flies towards the body, attracted to the decay. In this macabre still life, the implied odours that the frog gives off contribute to the *vanitas* discourse. Owing to their uncharacteristic smell, frogs may not yield many

olfactory results. However, by mining for flies in imagery, representations of putrefaction can be discovered.

Fig. 7



Ambrosius Bosschaert the Younger, *Dead Frog with Flies*, c. 1630, oil on copper, 12.5 x 17.5 cm  
Paris, Fondation Custodia, Collection Frits Lugt

- 31 The presence of a fly, however, is a visual trope known as *musca depicta* (Latin for “painted fly”), which especially concerns the earlier parameters of Odeuropa’s period of research. Among the interpretations, it was used by artists as a rhetorical gesture for their illusionistic skill. An accurately painted life-sized fly could be a *topos* to illustrate the artist’s ability to depict nature to the point of tricking the eye<sup>54</sup>. The multivalent interpretations of the fly dilute the olfactory imagery with other symbolic meaning. The images that computer vision extracts will therefore display varied amounts of olfactory references<sup>55</sup>. It should therefore be emphasised that computer vision will not be prescriptive on whether an image does or does not refer to the olfactory. Computer vision will yield more results that do not relate to olfaction, however it is one of the most efficient methodologies to identify images relating to odour.
- 32 There are also certain objects that have stronger olfactory connotations, however their representations make it remarkably challenging to be sourced by computer vision. For instance, handkerchiefs were used to block out foul smells, or were even covered in scented waters to relieve the nose. In medical contexts, handkerchiefs are depicted holding smelling salts or vinegar, to rouse patients<sup>56</sup>. As above, the handkerchief may have multivalent roles in an artwork (such as for adornment, cleaning, and to blot tears), however the difficulty lies before the interpretation can even take place, as handkerchiefs take on a remarkably wide variety of forms. The textile can be draped in innumerable poses, and change its shape as the hand pleases. Its inconsistency in form means that it is too difficult to train computer vision technology to recognise

handkerchiefs<sup>57</sup>. The closest way in which the technology will be able to find examples of handkerchiefs will also probably be the most informative depictions, in terms of olfactory history: the “Gestures” category below will be able to identify depictions of handkerchiefs held up to the nose, where it carries out its role of blocking out odours. In these instances, the role of the handkerchief, and therefore the allusions to the olfactory, will be at its clearest.

## Challenges for olfactory iconographies

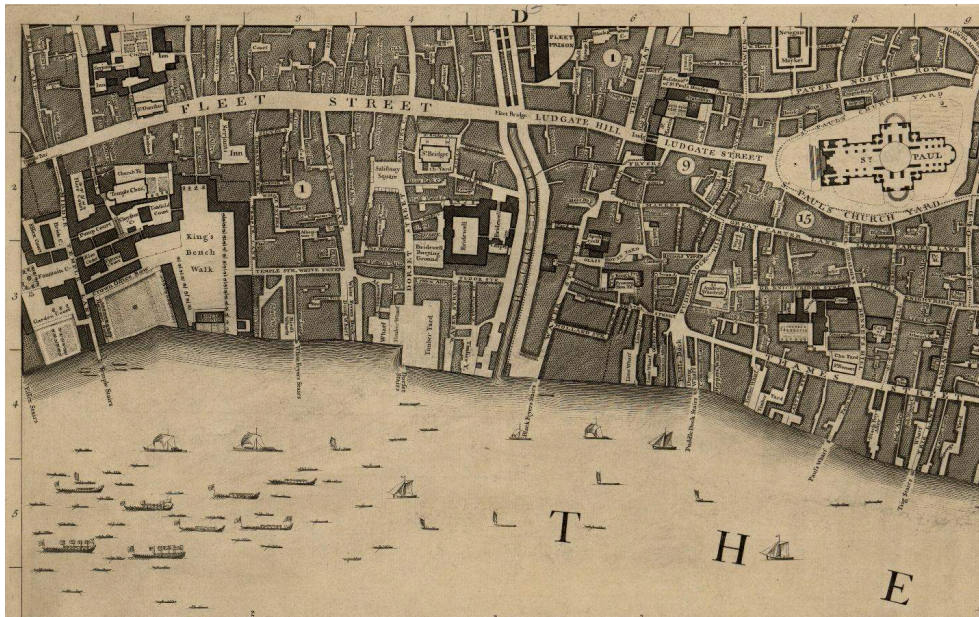
- 33 As discussed above, some iconographic narratives, like the Raising of Lazarus, have textual representations in which smell is explicitly mentioned. In other cases, iconographic depictions might contain an olfactory dimension which is not immediately evident. For instance, although the scents of the Garden of Eden are not detailed in the book of Genesis, artists may include a great deal of olfactory information concerning the imagined scents of Eden, through the scents they refer to in the scene. While computer vision can be helpful to a point<sup>58</sup>, there are opportunities to work with Iconclass and computer scientists that investigate and formalise iconographic knowledge in order to uncover lesser-known symbolic dimensions of smell in iconographies and their visual representations<sup>59</sup>. As discussed earlier, these developments are taking place when Iconclass is re-examining the terminology used in the classification system. It will be possible to enhance Iconclass codes with olfactory information, ultimately expanding olfactory iconographies<sup>60</sup>.

## Challenges for fragrant places

- 34 Landscapes, topographical images, domestic scenes, and views of street-life all offer interesting material for thinking about space and smell. However, they are of course representations that seek to encourage a particular way of seeing places – and therefore a particular type of olfactory gaze<sup>61</sup>. Cartography, for example, is a visual medium that often operates as a form of deodorization: contrast the clean, blank, orderly, scent-less Fleet Street on John Rocque’s 1746 map of London (fig. 8),<sup>62</sup> with William Hogarth’s street-level depiction of burning bonfires at one end of the thoroughfare (fig. 9),<sup>63</sup> or John Swift’s poetic description of the fleet ditch at the other where “Filths of all hues and odours seem to tell/ What street they sail’d from by their sight and smell”<sup>64</sup>. In analysing the smellscape represented in images we are not dealing with transparent depictions. This makes it harder to “stack” multiple depictions of one presumed odorous space on the other or to directly compare them.



Fig. 8



John Rocque, *A Plan of the Cities of London and Westminster, and Borough of Southwark, with the Contiguous Buildings* (detail), 1746, engraving, 2030 x 3850 mm on 24 sheets 770 x 570 mm  
Washington D. C., Library of Congress

Fig. 9



William Hogarth, *Burning the Rumps at Temple Bar* (Twelve Large Illustrations for Samuel Butler's *Hudibras*), pl. 11, 1725-1768, etching and engraving, 277 x 514 mm  
Harris Brisbane Dick Fund, 1932, New York, The Metropolitan Museum of Art

35 Outside of topographical illustrations, places tend to foreground the most important activity, and the background activity may be auxiliary to the scene. At present, the technology cannot discriminate between the prominence of an olfactory feature, meaning that it may be able to source imagery with major as much as minor olfactory atmospheres. For instance, the train shed will be one of the places that will be mined for its olfactory properties, as it once enclosed the scent of burning coal. The

aforementioned *Gare St-Lazare* foregrounds two steam trains (fig. 6). Through animated brushstrokes, Monet renders the smoke released by the train, and there is a strong suggestion that the space is concentrated in smoke. However, were computer vision to detect trains depicted far in the background, the olfactory significance of the depicted space may not have quite the same weight.

## Challenges for olfactory gestures

- 36 By depicting immediate reactions to smell, gestures presumably provide the most insightful visual references to smell available to us. Automatically detecting smell gestures, however, is even more difficult than the detection of olfactory objects. Compared to objects, depictions of gestures cannot as easily be localised on an image and require more contextual information for their recognition. Well established object detection algorithms thus cannot be directly applied. While gesture recognition in videos, especially for hands, is an active field of research<sup>65</sup>, the recognition of gestures from singular images is a relatively unusual endeavour. Thus, the approach of starting with off-the-shelf algorithms, and adapting them for their application on historical imagery that we have applied for olfactory objects, is not an option for gesture recognition. Instead, we must rely on indirect approaches that leverage the results of object detection or pose estimation, a technique to analyse human poses on images by predicting body keypoints<sup>66</sup>.
- 37 Smelling can be represented by blocking the nose in disgust, raising something to the nose, or inclining the nose towards an object of interest. A sniffing gesture might be recognised by detecting the sniffing person's face, their hand, and the object that is being sniffed on, such as a flower or melon, depicted in fig. 3. This approach requires a preliminary art historical analysis where we identify a set of objects that are candidates for being sniffed. If we then analyse the spatial relationship between the face, hand, and object, we might be able to distinguish cases where these objects are present in the image but not related to a sniffing gesture (such as the melons in the basket that the woman holds in fig. 3), from cases where a person brings an object to the nose to inhale its smell (the melon that the gentleman sniffs). While on the one hand, this poses an opportunity for art historians to collaborate with computer scientists to guide the artificial intelligence, preselecting olfactory objects might also include a bias and limit the scope of our findings: there may be other olfactory objects depicted in smelling gestures, but the art historians cannot provide the training data for the software to work with. Another approach is to apply pose estimation, a computer vision technique that finds key points to recognise poses of figures depicted in an image, to identify specific smell gestures such as sniffing, or blocking the nose<sup>67</sup>. During preliminary trials, the pose estimation was able to register the nose pinching gesture, however it also identified hands clasped in prayer as an olfactory gesture. If the two techniques of object detection and pose estimation were combined, it will be possible for the technology to yield better results for olfactory gestures in imagery. Following this trail of combining multiple computer vision techniques, the recently published SniffyArt dataset provides a combination of person boxes, keypoints defining body posture, and smell gestures labels<sup>68</sup>.

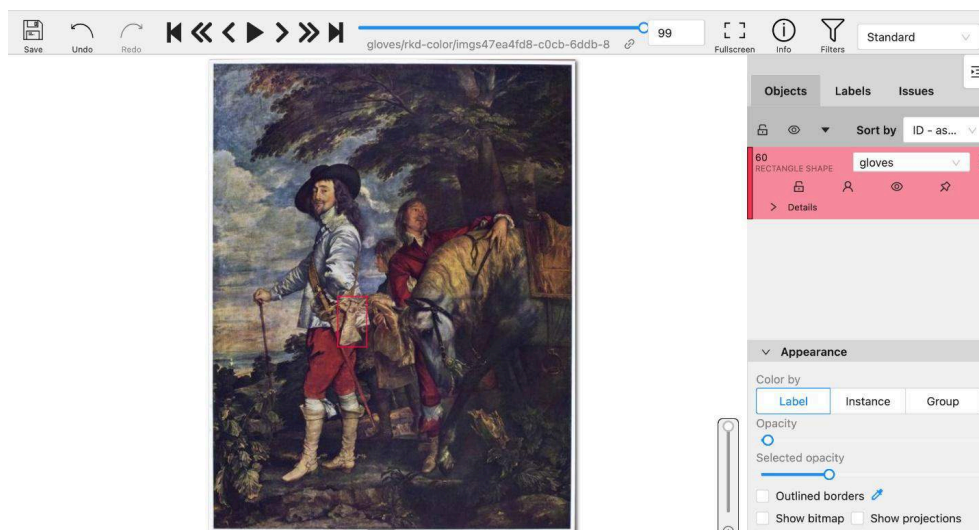
## Part Three: A computer vision case study

- 38 In a brief study, we will share how computer vision has identified olfactory references in works of art which can be sourced, and then used in heritage initiatives. It was discussed in the previous section that tanned leather gloves were particularly potent accessories. According to early modern techniques, after the animal skins used for glove making had been rinsed and removed of their hair through a treatment of lime paste and slaked lime<sup>69</sup>, the skins were softened by soaking them in warm water and an ammonia-rich substance of stale urine or manure. The skins were rinsed in running water, probably carrying the waste downstream. After soaking in a solution of fermented wheaten flour of bran, certain skins were dressed in fish oil to the point of complete absorption, or treated with the less offensive scents of alum or vegetable extracts. The odorous materials and processes involved in tanning were one reason why tanneries, like other foul-smelling industries, were strategically positioned on the outskirts of the city where the fumes could be carried away by the prevailing winds<sup>70</sup>. The innovations that the tanning procedure underwent in the 19<sup>th</sup> century rid it of the reliance on manure, urine, and lime in exchange for chromium sulphate, a chemical that left less of an odoriferous residue, resulting in the quintessentially “leather” scent known today. Traditional tanned leather, on the other hand, bears the potent scent of the materials used in the tanning treatment. Even decades on, the residual scent is perceptible<sup>71</sup>.
- 39 Such a process explains why there was a demand for scenting leather in the early modern period. In addition to household cookbooks, books of secrets, which, over the course of the early modern period were translated and republished, were replete with recipes to scent leather<sup>72</sup>. The book of secrets by Girolamo Ruscelli (1518-1566), who went by the pseudonym Alessio Piemontese, was first published in Venice in 1555. It gained a broad European readership through its translation into no less than nine languages from 1557 to 1791<sup>73</sup>. The work includes recipes to scent gloves, “wyth litle cost, and yet will continue longe”, and a civet-based recipe<sup>74</sup>. The process is arduous and time consuming: it consists of rubbing civet along the skin’s seams, washing the skin two to three times in rosewater, soaking them in a mixture of rose water, myrtle blossom and orange blossom water, in addition to cypress powder. Once half-dry, they are then rubbed with civet and oil of jasmine, until fully absorbed. They are then suspended over smoking incense, three times a day over twenty days. The skin is then anointed with a heated mixture of musk, amber, jasmine or ben oil, and perfumed water. After the seams are again rubbed with civet, the gloves are laid in dried roses for several days.
- 40 The gloves were costly not only due to being leather goods, but also in the labour that it required to fragrance them, as well as the range and quantity of costly ingredients to override the scent of tanned leather. On account of their luxury, gloves could be gifted to love interests, they were presented as a part of diplomatic strategy, and offered as prize winnings for competitions among the elite<sup>75</sup>. The depiction of gloves in early modern portraits are therefore thought to express power and status, due to their luxuriousness<sup>76</sup>. In visual terms, the gloves make up only a fraction of the painting, however in olfactory terms, the gloves’ scent must have been the prevailing odour in the scene. In this way, the accessory’s scent compounds the expression of luxury. Viewing such a portrait in a domestic or public context, an early modern subject would

have brought this olfactory knowledge to their interpretation of the image. It was a viewing experience that might have been heightened by the lingering scents of the viewer's own gloves.

- 41 Mining for gloves in image databases was therefore a high priority for Odeuropa. In order to train computer vision algorithms to source gloves, a collection of artworks that depicted gloves from between 1600-1920 were gathered using collection database search engines. 371 bounding boxes were drawn over the 323 images to annotate where the gloves were located in the works (fig. 10). The diversity of the gloves' colours, style, and poses all contributed to strengthening the training of the detection model. Test runs were then carried out, where computer vision was trialed with the unannotated collection of gloves, to ascertain how many gloves it could identify. The results were relatively positive with a mean average precision (mAP<sub>50</sub>) of 55.8%<sup>77</sup>. It suggests that using computer vision on datasets in this way cannot return completely accurate results, and that once the images are sourced, it requires some work to review the results. The advantage, however, is that it will be possible to mine large image databases and draw out a collection of images that are more expansive than through individual efforts. Additionally, the annotated gloves have been integrated in version one of the dataset of olfactory imagery discussed above.

Fig. 10



Using the Computer Vision Annotation Tool (CVAT) programme, a bounding box demarcates the glove in Anthony van Dyck's portrait of Charles I, from Musée du Louvre, Paris

- 42 One of the aims of mining for the olfactory in imagery is for the benefit of museums and heritage collections. The "Impact" strand of Odeuropa collaborated with Stefanie Dathe and Eva Leistenschneider of Museum Ulm, Ulm, to devise an olfactory tour of their permanent collection. The tour threads together works across several centuries, from c. 1480, to 1964/1965, creating a new route to explore the chronologically-ordered galleries. It also involves different geographies, with works by local Ulm artist Martin Schaffner, in addition to Swiss artist Daniel Spoerri, and different media that range from found objects to oil paintings. One stop on the tour includes a portrait where perfumed gloves are depicted. The portrait of Helena Schermer (née Baldinger, 1599-1683) is displayed in the museum alongside a pendant of her husband, Anton Schermer (1604-1681) (figs. 11-12)<sup>78</sup>. The Ulm patricians married in 1628, and their

partnership lasted for over fifty years. As was with double portraits in the period, the painting was probably produced in honour of their wedding, therefore dating the works to around 1628. We know that Anton Schermer was a reader and writer of theological literature, and an avid coin collector, however little is known of the life of Helena<sup>79</sup>. Exploring the perfumed gloves that she holds, however, can help with getting closer to her history, through sensory experience.

Fig. 11



Andreas Shuch, *Portrait of Anton Schermer*, c. 1628, oil on canvas, 100 x 82 cm  
Ulm, Museum Ulm

Fig. 12



Andreas Schuch, *Portrait of Helena Schermer*, c. 1628, oil on canvas, 100 x 82 cm  
Ulm, Museum Ulm

- 43 Helena is depicted with an ample ruff and golden chains around her neck. Jewelled bracelets decorate her wrists, and no less than four gem rings decorate her fingers. Clasped between her hands are a pair of gloves made of white leather, with embroidered red gauntlets. They count as another luxury in the painting. As German translations of Rucelli's book of secrets were regularly printed from 1569, it was considered to be one of the available recipes closest to the scent that might have lingered in Helena's gloves<sup>80</sup>. Working in collaboration with IFF (International Flavors and Fragrances), the fragrance recipe described earlier was transcribed and shared with perfumers, who used the ingredients' essences to produce a formula that gave an impression of how the gloves may once have smelled<sup>81</sup>. As Rucelli's recipe is rarely specific about the ingredients' quantities, the perfumers could measure them at their discretion<sup>82</sup>. To give a fuller understanding of the historic process of producing gloves, a second scent that evoked the smell of tanned leather was also produced.
- 44 When the scents are distributed on the tour, it brings a new dimension to the experience of the painting. While the documentation about Anton Schermer is relatively rich, Helena Schermer is now reunited with some of her own history, by the reactivation of the scent of her gloves. Through artificial intelligence we can link Helena's gloves into a rich and expansive story that crosses hundreds of portraits across a wide range of collections – portraits that are linked by the presence of similarly scented accessories. Museums and heritage institutions can take advantage of those links by re-scenting the images that appear in their own collections and, in doing so, offer both academic and non-academic audiences a new way of engaging with the visual culture of the past<sup>83</sup>.

## Conclusion: Using olfactory imagery

- 45 This article has explored the methodology that Odeuropa has created in order to mine digital collections of olfactory imagery. The challenges that we faced in employing the AI technology have raised questions about what it means to source the olfactory in imagery. For instance, does the significance of the olfactory change according to its prominence in an image? How far do iconographies allude to the olfactory? And do olfactory objects hold other meanings that may not be related to smell? The point where the challenges cannot be overcome by computer vision is where the interpretation and analysis from scholars can begin.
- 46 Tracing the perfumed gloves from image database to olfactory museum tour is emblematic of the ways in which artificial intelligence can be used in museum and heritage initiatives. Picturing olfactory experiences means exploring image collections in a way that brings together images across period and region through a fresh approach: an olfactory object like tobacco can elaborate on the history of its consumption by tracing it through a broad range of imagery over the centuries, from scenes of snuff taking, to cigarette advertisements. But perhaps an even more unusual but promising approach is tracing a specific odorant in imagery. Frankincense, for instance, can be identified in imagery spanning from mythology, biblical stories, allegories, as well as scenes of fragranced household interiors. Indole, the compound found in lilies, can also be identified in the scent of putrefaction, drawing together sacred imagery of the Annunciation with scenes of anatomical dissections. Such threads taken from the imagery can present new ways of looking and understanding the past, exploring the rhymes and resonances of odours on their own terms. By addressing the olfactory similarities in imagery, we may also revive past associations and connections between apparently disparate imagery. It is the agility of the olfactory in imagery that can create new storylines and interpretations for scholarship and museum and heritage initiatives alike. We await more stories to join Helena Schermer and her perfumed gloves.

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## NOTES

1. Sofia Colette Ehrich, *et al.*, “Nose First. Towards an Olfactory Gaze for Digital Art History”, in Sara Carvalho and Renato Rocha Souza (dir.), *MDK21: 1st International Workshop on Multisensory Data & Knowledge*, 2021, p. 1-17, doi: 10.4230/OASICS.MDK.2021.6.
2. Matthew J. Pachomius Meade, *The Depiction of Smell in Fifteenth-Century Netherlandish Painting as Cultural Sense Memory and Odor-Cued Prayer Context*, MA thesis, Columbia, University of Missouri, 2016.
3. Claire Dobbin and Leslee Katrina Michelsen, “Engaging the Olfactory: Scent in the Arts, Cultures, and Museums of the Islamic World”, in Heather Hunter-Crawley and Erica O’Brien (dir.), *The Multi-Sensory Image: From Antiquity to the Renaissance*, London, Routledge, 2019, esp. p. 107-118.

4. Nina Ergin, “The Fragrance of the Divine: Ottoman Incense Burners and Their Context”, *The Art Bulletin*, vol. 96, n° 1, 2014, p. 70-97.
5. François Quiviger, “Allegories”; “Smell”, in *The Sensory World of Italian Renaissance Art*, London, Reaktion Books, 2010, p. 88-96 and p. 125-135.
6. Ariane van Suchtelen (dir.), *Fleeting – Scents in Colour*, exhibition catalogue. The Hague (Mauritshuis), Zwolle, Waanders, 2021; Elizabeth Marx, *Visualising, Perceiving and Experiencing Smell in Seventeenth-Century Dutch Art*, PhD thesis, Cambridge, University of Cambridge, 2022. See also Herman Roodenburg, “Smelling Rank and Status”, in Ronni Baer, *Class Distinctions: Dutch Painting in the Age of Rembrandt and Vermeer*, exhibition catalogue, Boston (Museum of Fine Arts Boston), Boston, MFA Publications, 2015.
7. See, for instance, Érika Wicky, “La peinture à vue de nez ou la juste distance du critique d’art, de Diderot à Zola”, *Revue d’art Canadienne*, vol. 39, n° 1, 2013, p. 76-89; Érika Wicky, “Les parfums de l’Ancien Régime: Persistance et représentations au dix-neuvième siècle”, in Marine Ganofsky, Jean-Alexandre Perras (dir.), *Le siècle de la légèreté: Émergences d’un paradigme du XVIII<sup>e</sup> siècle*, Liverpool, Liverpool University Press, 2019, p. 267-285.
8. Christina Rain Bradstreet, *Scented Visions: The Nineteenth-Century Olfactory Imagination*, PhD thesis, London, Birkbeck College, University of London, 2008; Christina Bradstreet, *Scented Visions: Smell in Art, 1850-1914*, University Park, Penn State University Press, 2022.
9. Caro Verbeek, *Ruiken aan de tijd: De olfactorische dimensie van het futurisme (1909-1942)*, PhD thesis, Amsterdam, Vrije Universiteit, 2020.
10. See, for instance, Jim Drobnick, *The Smell Culture Reader*, Oxford, Berg Publishers, 2006; Larry Shiner, “Sublime Stenches: Contemporary Olfactory Art”, in *Art Scents: Exploring the Aesthetics of Smell and the Olfactory Arts*, Oxford, Oxford University Press, 2020. For a review of the latest research in olfactory history, see William Tullett, Inger Leemans, et al., “AHR Conversation: Smell, History, and Heritage”, *American Historical Review*, vol. 127, n° 1, 2022, p. 261-309. For a growing bibliography, see the “PastScent Bibliography”: <https://odeuropa.eu/pastscent-bibliography/> (accessed November 22, 2023).
11. J. Douglas Porteous established the term smellscape to refer to smells that are bound to a time and place. (J. Douglas Porteous, “Smellscape”, *Progress in Human Geography*, vol. 9, n° 3, 1985, p. 356-378).
12. At the end of 2023, the “Impact” strand published an online, open access resource that provides a starting point for cultural heritage professionals to use scent as a storytelling technique in GLAMs (Galleries, Libraries, Archives, and Museums). (“Olfactory Storytelling Toolkit: A “How-To” Guide for Working with Smells in GLAMs and Heritage Institutions”, <https://odeuropa.eu/the-olfactory-storytelling-toolkit/>, accessed November 22, 2023).
13. Charles Spence, “Scenting the Anosmic Cube: On the Use of Ambient Scent in the Context of the Art Gallery or Museum”, *I-Perception* 2020, vol. 11, n° 6, p. 1-26, doi: 10.1177/2041669520966628; Constance Classen, *The Museum of the Senses: Experiencing Art and Collections*, London, Bloomsbury, 2017.
14. Sissel Tolaas, “An Alphabet for the Nose”, <https://www.researchcatalogue.net/view/7344/7350> (accessed November 22, 2023); Mandy Aftel, “Aftel Archive of Curious Scents” (<https://www.aftelier.com/Articles.asp?ID=256>, accessed November 22, 2023); Patricia de Nicolai, “Professionnels: Que deviennent les parfums que vous nous confiez?”, *Les nouvelles de l’Osmothèque*, vol. 57, 2011, p. 1-4, [https://www.osmotheque.fr/wp-content/themes/lanfoster\\_template/download/Que-deviennent-vos-parfums-article.pdf](https://www.osmotheque.fr/wp-content/themes/lanfoster_template/download/Que-deviennent-vos-parfums-article.pdf), accessed November 22, 2023).
15. Miranda Stearn, “Contemporary Challenges: Artistic Interventions in Museums and Galleries Dealing with Challenging Histories”, in Jenny Kidd et al. (dir.), *Challenging History in the Museum*, London, Routledge, 2016, p. 102-104; see the following search in the catalogue, (<https://www.britishmuseum.org/collection/search?keyword=bouche&keyword=du&keyword=roi>,



accessed November 22, 2023). When the work was later displayed at the Rijksmuseum, Amsterdam, for the 2021 *Slavery* exhibition, the olfactory aspects were noted. Eveline Sint Nicolaas, “Dutch Colonial Slavery”, in Eveline Sint Nicolaas and Valika Smeulders (dir.), *Slavery*, exhibition catalogue. Amsterdam (Rijksmuseum), Amsterdam, Atlas Contact, 2021, p. 42-43.

16. Charles Jeurgens, “The Scent of the Digital Archive: Dilemmas with Archive Digitisation”, *Bijdragen en Mededelingen betreffende de Geschiedenis der Nederlanden*, vol. 128, n° 4, 2013, p. 30-54.

17. André Malraux, *Voices of Silence*, trans. Stuart Gilbert, London, Paladin, 1974 [orig. ed. *Les voix du silence*, Paris, Gallimard, 1951], p. 13-130.

18. William J. Turkel, “Intervention: Hacking History, from Analogue to Digital and Back Again”, *Rethinking History*, vol. 15, n° 2, 2011, p. 287-296.

19. “ODOTHEKA-Exploring and Archiving Heritage Smells” (<https://hslab.fkkt.uni-lj.si/2021/09/24/odotheka-exploring-and-archiving-heritage-smells/>, accessed November 22, 2023)

20. Anna Chen, “Perfume and Vinegar: Olfactory Knowledge, Remembrance, and Recordkeeping”, *The American Archivist*, vol. 79, n° 1, 2016, p. 103-120; Mathilde Castel, *La muséologie olfactive: Une actualisation résonante de la muséologie de Stránský par l’odorat*, PhD thesis, Paris, Université Sorbonne Nouvelle Paris 3, 2019, p. 213-278.

21. Cara Krmpotich, “The Senses in Museums”, in Robin Skeates and Jo Day (dir.), *The Routledge Handbook of Sensory Archaeology*, London, Routledge, 2019, p. 94-106.

22. *Ibid.*, p. 100-104.

23. Cecilia Bembibre Jacobo *et al.*, “Smelling the Past: A Case Study for Identification, Analysis and Archival of Historic Pot-Pourri as a Heritage Smell”, in Janet Bridgland (dir.), *ICOM-CC 18th Triennial Conference Preprints, Copenhagen, 4-8 September 2017*, Paris, International Council of Museums, 2017.

24. Cecilia Bembibre and Matija Strlič, “Smell of Heritage: A Framework for the Identification, Analysis and Archival of Historic Odours”, *Heritage Science*, vol. 5, n° 1, 2017, p. 1-11.

25. <https://iconclass.org/> (accessed November 22, 2023).

26. Leendert D. Couprie, “Iconclass: An Iconographic Classification System”, *Art Libraries Journal*, vol. 8, n° 2, 1983, p. 32-49. For a description of more recent usages of the Iconclass system see Hans Brandhorst and Etienne Posthumus, “Iconclass: A Key to Collaboration in the Digital Humanities”, in Colum Hourihane (dir.), *The Routledge Companion to Medieval Iconography*, London, Routledge, 2016, p. 201-218.

27. Sofia Colette Ehrich *et al.*, “Nose First”, *op. cit.*, p. 7.

28. Cf. Iconclass codes 71G113 *The anointing of Saul by Samuel* (<https://iconclass.org/71G113>, accessed November 22, 2023), and 71H115 *Samuel anointing David in the presence of his father Jesse and his brothers* (<https://iconclass.org/71H115>, accessed November 22, 2023)

29. For an excellent summary and discussion, see “Iconclass and Sensory History”, (<https://forum.iconclass.org/t/iconclass-and-sensory-history/15>, accessed November 22, 2023).

30. Nina Levent and Alvaro Pascual-Leone (dir.), *The Multisensory Museum: Cross-Disciplinary Perspectives on Touch, Sound, Smell, Memory, and Space*, Lanham, Rowman & Littlefield, 2014, p. xiv, 3.

31. Note that the field of computer vision has a tradition that goes well beyond the advent of ubiquitous deep learning techniques. See Richard Szeliski, *Computer Vision: Algorithms and Applications*, Cham, Springer, 2010 for an overview that includes both traditional and machine learning-based approaches to computer vision.

32. Christian Dieter Sauer, “Smell and Taste in Art: Suggestions Towards a Systematic Approach”, *Ikonotheka*, vol. 29, 2019, p. 151-174 (esp. p. 158-159).

33. Quentin Buvelot and Carola Vermeeren, *Royal Picture Gallery Mauritshuis: A Summary Catalogue*, Zwolle, Waanders, 2004, cat. 1045.

34. This corresponds to David Parkin’s suggestion that ephemeral smells can become “complete” (in this case, visualised) when it is concentrated into its physical source from which it came.

(David Parkin, “Wafting on the Wind: Smell and the Cycle of Spirit and Matter”, *The Journal of the Royal Anthropological Institute*, vol. 13, 2007, p. 39-53, here p. 45-46).

35. John 11:39.

36. Nicholas Turner, *The Paintings of Guercino. A Revised and Expanded Catalogue Raisonné*, Rome, Ugo Bozzi Editore, 2017, cat. 77. Another example of an olfactory iconography is the Adoration of the Magi, where the Christ Child is presented with gold and two aromatic resins: frankincense and myrrh (Matthew 2:11). The identification of olfactory iconographies in the Odeuropa project is supported by the expert knowledge of (art) historians and by the text mining strand, which is gathering new information on olfactory practices and symbolism in the past.

37. Malcolm Cormack, *A Concise Catalogue of Paintings in the Yale Center for British Art*, New Haven, Yale Center for British Art, 1985, cat. N590.2 A83.

38. Jacques Lassaingne and Fiorella Minervino, *Tout l'œuvre peint de Degas*, Paris, Flammarion, 1988, cat. 966.

39. Friedrich Wilhelm Hollstein, *Dutch and Flemish Etchings, Engravings and Woodcuts ca. 1450-1700*, vol. 7, Amsterdam, Menno Hertzberger, 1952, cat. 263.

40. A more formal analysis of the challenges associated with domain differences between photographic and artistic imagery can be found in Elliot J. Crowley and Andrew Zisserman, “The State of the Art: Object Retrieval in Paintings Using Discriminative Regions”, in Michel Valstar, Andrew French, and Tony Pridmore, *Proceedings of the British Machine Vision Conference*, Guildford, BMVA Press, 2014.

41. The painted flowers were said to be so realistic that viewers at the time were able to perceive their smells. (Lizzie Marx, “Odours in Art – Depicting the Invisible”, in Ariane van Suchtelen, *Fleeting*, op. cit., p. 48)

42. Daniel Wildenstein, *Claude Monet: Biographie et catalogue raisonné*, vol. 1, Lausanne, La Bibliothèque des Arts, 1974, cat. 440.

43. Most notably the CLIP architecture which is trained to pair images with captions, see Alec Radford, et al., “Learning Transferable Visual Models from Natural Language Supervision”, *Proceedings of the 38th International Conference on Machine Learning*, PMLR 139, 2021, doi: 10.48550/arXiv.2103.00020.

44. Abhishek Mandal, Susan Leavy, and Suzanne Little, “Measuring Bias in Multimodal Models: Multimodal Composite Association Score”, in Ludovico Boratto et al. (dir.), *Bias 2023: Advances in Bias and Fairness in Information Retrieval*, Springer, Cham, 2023, doi: 10.1007/978-3-031-37249-0\_2.

45. We have tried to apply the text-based query tool [imgs.ai](https://imgs.ai) (<https://imgs.ai>, accessed November 22, 2023) which leverages both textual and visual information but received only few meaningful results. However, in the future we want to keep experimenting with multimodal methods. For a detailed explanation of the query tool see Fabian Offert and Peter Bell, “Imgs.Ai. A Deep Visual Search Engine for Digital Art History”, in *International Journal for Digital Art History* (forthcoming). See also Leonardo Impett and Fabian Offert, “There Is a Digital Art History”, *arXiv preprint*, 2023, doi: 10.48550/arXiv.2308.07464.

46. Experiments in overcoming this domain shift for the detection of olfactory objects have recently been presented by this article’s co-author. (Mathias Zinnen et al., “Transfer Learning for Olfactory Object Detection”, *ADHO Digital Humanities Conference*, Tokyo, 2022, p. 409-413, doi: 10.48550/arXiv.2301.09906).

47. Recently, style transfer for computer vision on artworks has successfully been applied by Hyeong-Ju Jeon et al., “Object Detection in Artworks Using Data Augmentation”, *2020 International Conference on Information and Communication Technology Convergence (ICTC)*, IEEE, 2020, p. 1312-1314; Prathmesh Madhu et al. “Recognizing Characters in Art History Using Deep Learning”, *Proceedings of the 1st Workshop on Structuring and Understanding of Multimedia HeritAge Contents*, 2019, doi: 10.1145/3347317.3357242.

48. For an overview, see Longlong Jing and Yingli Tian, “Self-Supervised Visual Feature Learning with Deep Neural Networks: A Survey”, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 43, n° 11, 2021, p. 4037-4058; Xiao Liu *et al.*, “Self-Supervised Learning: Generative or Contrastive”, *IEEE Transactions on Knowledge and Data Engineering*, 2021, doi: 10.1109/TKDE.2021.3119326.
49. See William Tullett, *Smell in Eighteenth-Century England: A Social Sense*, Oxford, Oxford University Press, 2019, p. 68-69, 117-120, 124-125, 131-134, 145-147. Here, it will be possible to take advantage of the images’ metadata, where the olfactory references included in the prints’ text are noted. On depicting ephemeral smoke in engraving, see Michael Gaudio, “Making Sense of Smoke: Engraving and Ornament in de Bry’s ‘America’”, in *Engraving the Savage: The New World and Techniques of Civilization*, Minneapolis, University of Minnesota Press, 2008, esp. p. 49-53.
50. One recent example for the application of computer vision techniques to study imagery in newspapers is Melvin Wevers and Thomas Smits, “The Visual Digital Turn: Using Neural Networks to Study Historical Images”, *Digital Scholarship in the Humanities*, vol. 35, n° 1, 2020, p. 194-207, doi: 10.1093/llc/fqy085.
51. A continuously updated list of candidate objects is available at: [http://vocab.odeuropa.eu/olfactory\\_objects/en/](http://vocab.odeuropa.eu/olfactory_objects/en/) (accessed November 22, 2023).
52. Mathias Zinnen *et al.*, “Odeuropa Dataset of Smell-Related Objects (1.0.3)”, doi: 10.5281/zenodo.6367776. A subset of the dataset was used in an object detection competition where participants were asked to submit systems capable of detecting the categories across a set of 2647 artworks. Mathias Zinnen *et al.*, “Odor: The ICPR2022 Odeuropa Challenge on Olfactory Object Recognition”, in: *2022 26<sup>th</sup> International Conference on Pattern Recognition (ICPR)*, Montreal, 2022, p. 4989-4994, doi: 10.48550/arXiv.2301.09878.
53. Laurens J. Bol, *The Bosschaert Dynasty: Painters of Flowers and Fruit*, Lewis, Leigh-on-Sea, 1960, cat. 32.
54. See Kandace Rawlings, “Painted Paradoxes: The ‘Trompe-L’Oeil’ Fly in the Renaissance”, *Athanon*, vol. 26, 2008, p. 7-13.
55. See also Sofia Colet Ehrich *et al.*, “Nose First”, *op. cit.*, p. 10-11.
56. Paolo Peri, *The Handkerchief*, Modena, Zanfi Editori, 1992, p. 16; Evelyn Welch, “Scented Buttons and Perfumed Gloves: Smelling Things in Renaissance Italy”, in Bella Mirabella (dir.), *Ornamentalism: The Art of Renaissance Accessories*, Ann Arbor, University of Michigan Press, 2011, p. 26.
57. A similar challenge is presented with depictions of smoke and clouds of odour. Their changeable, obscuring forms are difficult to detect by computer vision. However, the objects, or sources, from which the smoke comes from can be mined instead. Again, note that multimodal approaches might alleviate this issue and hold the potential to recognise a considerably larger number of objects in the future. On depicting smoke, see also n° 49 above.
58. See for example Prathmesh Madhu *et al.*, “Understanding Compositional Structures in Art Historical Images Using Pose and Gaze Priors”, in Adrien Bartoli and Andrea Fusiello (dir.), *Computer Vision – ECCV 2020 Workshops*, part 2, Cham, Springer, 2020.
59. On how knowledge of symbolic meanings can be converted into knowledge graphs and fed into image classification systems such as Iconclass, see Bruno Sartini, Marieke van Erp and Aldo Gangemi, “Marriage is a Peach and a Chalice: Modelling Cultural Symbolism on the Semantic Web”, *K-CAP ’21: Proceedings of the 11th on Knowledge Capture Conference*, December 2021, p. 201-208.
60. We extend our thanks to Hans Brandhorst for sharing his helpful insights.
61. The term “olfactory gaze” was coined by Bradstreet in *Scented Visions*, 2008, *op. cit.*, p. 99, and has since been adopted by Verbeek, as “*olfactorische blik*”, in Caro Verbeek, *Ruiken aan de tijd*, *op. cit.*, esp. p. 9-12.
62. Washington D. C., Library of Congress, inv. G5754.L7 1746 .R6.
63. Ronald Paulson, *Hogarth’s Graphic Works*, vol. 2, London, The Print Room, 1989, cat. 92.

64. William Tullett, *Smell in Eighteenth-Century England*, *op. cit.*, p. 60-61.
65. See Munir Oudah, Ali Al-Naji, and Javaan Chahl, “Hand Gesture Recognition Based on Computer Vision: A Review of Techniques”, *Journal of Imaging*, vol. 6, n° 73, 2020, doi: 10.3390/jimaging6080073.
66. For an overview, see Ce Zheng *et al.*, “Deep Learning-Based Human Pose Estimation: A Survey”, *arXiv Preprint arXiv:2012.13392*, 2022, doi: 10.1145/1122445.1122456. Pose estimation in artworks has recently been applied by Prathmesh Madhu *et al.*, “Understanding Compositional Structures”, *op. cit.*
67. Leonardo Impett, “Analyzing Gesture in Digital Art History”, in Kathryn Brown (dir.), *The Routledge Companion to Digital Humanities and Art History*, New York, Routledge, 2020.
68. Mathias Zinnen *et al.*, “Sniffyart: The Dataset of Smelling Persons”, in *Proceedings of the 5th Workshop on AnalySis, Understanding and ProMotion of HeritAge Contents, SUMAC '23*, doi: 10.1145/3607542.3617357.
69. Incidentally, producing lime in kilns gave off smoke that was notoriously foul. The kilns were found on the outskirts of town, in order to divert the stench. Roos van Oosten and Sanne Muurling, “Smelly Business: De clustering van vieze en stinkende beroepen in Leiden in 1581”, *Holland: Historisch tijdschrift*, vol. 51, n° 3, 2019, p. 128-143, here p. 132.
70. *Ibid.*; Holly Dugan, *The Ephemeral History of Perfume: Scent and Sense in Early Modern England*, Baltimore, The Johns Hopkins University Press, 2011, p. 135-136.
71. Traditional leather tanning, namely in Morocco, has not vastly deviated in practice for hundreds of years. On the reconstruction of a historical tannery, see Yuanfa Dong *et al.*, “Multisensory Virtual Experience of Tanning in Medieval Coventry”, in Robert Sablatnig and Benjamin Štular (dir.), *EUROGRAPHICS Workshop on Graphics and Cultural Heritage*, Goslar, Eurographics Association, 2017.
72. See Holly Dugan, *Ephemeral History*, *op. cit.*, p. 151-152. See also James Daybell *et al.*, “Materiality in Early Modern English Gloves”, *The Sixteenth Century Journal*, vol. 52, n° 3, 2021, p. 571-606, here p. 584.
73. For all of the editions on Ruscelli's book, see Ad Stijnman, “A Short-Title Bibliography of the ‘Secreti’ by Alessio Piemontese”, in Sigrid Eyb-Green *et al.*, *The Artist's Process: Technology and Interpretation: Proceedings of the Fourth Symposium of the Art Technological Source Research Working Group*, London, Archetype, 2012, p. 32-47.
74. Alessio Piemontese, *The Secretes of the Reverende Maister Alexis of Piemount*, trans. Wyllyam Warde, London, John Kingstone, 1558 [orig. ed. *Secreti del reverendo donno Alessio Piemontese*, Venice, Sigismondo Bordogna, 1555], p. 59-60.
75. See Evelyn Welch, “Scented Buttons”, *op. cit.*, p. 17; James Daybell *et al.*, “Materiality in Early Modern English Gloves”, *op. cit.*, p. 597-605; Holly Dugan, *Ephemeral History*, *op. cit.*, p. 132-135.
76. James Daybell *et al.*, *op. cit.*, p. 596-597; Holly Dugan, *op. cit.*, p. 127-128.
77. Mean average precision (mAP<sub>50</sub>) is a standard metric for object detection methods, which takes into account both the number of detected objects in relation to all objects present (recall), and the ratio of correctly predicted objects (accuracy). The subscript 50 denotes that object predictions are considered correct if at least 50% of their surface area overlaps with the manually annotated “ground truth” object. For a more detailed definition of the metric please refer to <https://cocodataset.org/#detection-eval> (accessed November 22, 2023).
78. Ulm, Museum Ulm, inv. L 1970.9035; L 1970.9036.
79. Many thanks to Eva Leistenschneider for sharing her expertise on the paintings. See also Stefan Lang, “Bibliotheksstifter, Patriot und Kulturreisender. Anton Schermer (1604-1681), ein Ulmer Patrizier des 17. Jh”, *Ulm und Oberschwaben*, vol. 57, 2011, p. 169-199.
80. Ad Stijnman, “A Short Title Bibliography”, *op. cit.*

81. For further information on the development of the scent, see Lizzie Marx *et al.*, “Making Whiffstory: A Contemporary Re-creation of an Early Modern Scent for Perfumed Gloves”, *American Historical Review*, vol. 127, n° 2, 2022, p. 880-893.

82. Indeed, a reconstructed scent can never be completely experienced as it was in the past. However sensory experiences can allow us to get better acquainted with them. William Tullett, “State of the Field: Sensory History”, *History: The Journal of the Historical Association*, vol. 16, n° 373, 2021, p. 804-820 (808-809, 818-819). On the reconstruction of historical fragrances and their methodological challenges, see *Ibid.*; Ann-Sophie Barwich and Matthew Rodriguez, “Fashion Fades, Chanel No. 5 Remains: Epistemology Between Style and Technology”, *Wissenschaftsgeschichte*, vol. 43, n° 3, 2020, p. 267-384 (369-373).

83. For further approaches to re-scenting the past, see Inger Leemans *et al.*, “Whiffstory: Using Multidisciplinary Methods to Represent the Olfactory Past”, *American Historical Review*, vol. 127, n° 2, 2022, p. 848-879.

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## ABSTRACTS

How can artificial intelligence help to “see” smells in works of art? This article discusses the ways in which the Horizon 2020 Odeuropa project uses computer vision to search for olfactory imagery in digital heritage collections. It provides a literature review of the latest approaches to researching smell in art, and outlines the methodology for mining digital collections. It also raises questions about what it means to source smell in digital archives, the challenges encountered when working with the technology, and its possibilities. It concludes with a case study illustrating the potential of such an approach, where computer vision was used to find perfumed gloves in works of art, resulting in an olfactory guided tour of Museum Ulm.

Comment l'intelligence artificielle peut-elle aider à “voir” les odeurs dans les œuvres d'art ? Cet article traite de la manière dont le projet Horizon 2020 Odeuropa utilise la vision par ordinateur pour rechercher des images olfactives dans les collections du patrimoine numérique. Il présente les dernières recherches sur les odeurs dans l'art et décrit la méthodologie d'extraction de données dans les collections numériques. Il soulève également des questions sur ce que cela implique de “sourcer” une odeur dans les archives numériques, les défis que représente travailler avec ces technologies, mais aussi les opportunités de cette démarche. L'article se termine par une étude de cas illustrant les potentialités d'une telle approche, où la vision par ordinateur a été utilisée pour repérer des gants parfumés dans des œuvres d'art, ce qui a donné lieu à une visite guidée olfactive au Musée d'Ulm.

## INDEX

**Mots-clés:** vision par ordinateur, histoire de l'art sensoriel, patrimoine culturel, archives numériques, iconographie

**Keywords:** computer vision, sensory art history, cultural heritage, digital archives, iconography

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