Nose-First. Towards an Olfactory Gaze for Digital Art History

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Abstract

What are the historical smells and olfactory narratives of Europe? How can we make use of digital museum collections to trace information on olfactory heritage? In recent years, European cultural heritage institutions have invested heavily in large-scale digitization, which provides us with a wealth of object, text and image data that can be browsed and analysed by humans and machines. However, as heritage institutes, as well as humanities and computer science scholars, have had a long-standing tradition of ocular-centric thinking, it is difficult to find relevant information about smell in digital collections. The historical gaze, for a long time, has been visually biased, leaving smell overlooked within many digital collections.

This paper offers a roadmap towards an olfactory gaze for digital cultural heritage collections. The work we present here is part of the Odeuropa project, an action of the Horizon 2020 programme, which promotes research and innovation. It presents a work in progress on olfactory heritage and sensory mining in digital art collections. First, we will describe the current state of the art, showing how olfactory information is traditionally missing or even omitted from digital art collection management systems. We present a baseline research, which maps the gaps and biases in art thesauruses and iconographic classification systems. Next, we will present two connected solutions that we are currently developing in the Odeuropa project: a) a database with olfactory information related to historical artworks, aimed to enrich existing metadata and improve search solutions b) computer vision methodologies for sensory mining. Finally, we pitch a new idea: a nose-first scent wheel. When integrated into current digital collection interfaces, the scent wheel would encourage audiences to develop an olfactory gaze and offer new ways to uncover the rich storylines of olfactory heritage within digital collections.

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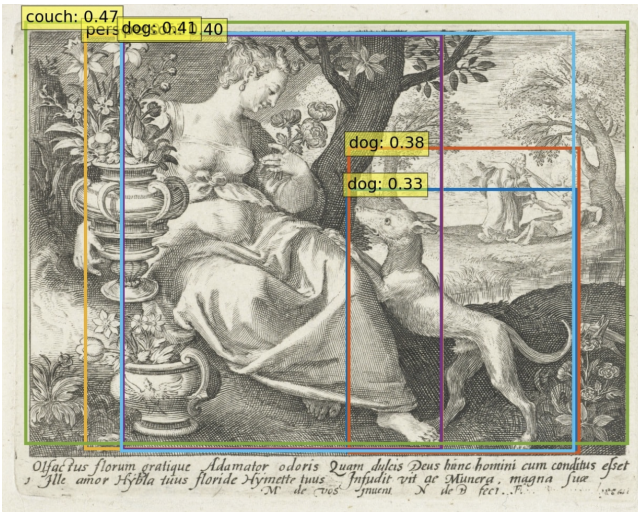

Figure 1 Computer vision techniques employed to extract olfactory information from historical artworks in digital heritage collections. Nicolaes de Bruyn (after a design by Maerten de Vos), Allegory of Smell (1581-1656). Rijksmuseum, Amsterdam, RP-P-BI-5098.

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1 Introduction

What are the historical smells and olfactory narratives of Europe? How can we make use of digital museum collections when tracing information on olfactory heritage? In recent years, European cultural heritage institutions have invested heavily in large-scale digitization, which provides us with a wealth of object, text and image data that can be browsed and analysed by humans and machines. However, as heritage institutes, as well as humanities and computer science scholars, have had a long-standing tradition of ocular-centric thinking, it is difficult to find relevant information about smell in digital collections [9]. The historical gaze, for a long time, has been visually biased, leaving smell overlooked within many digital collections [21].

This is a pity, as the notion of sensory heritage could help museums to enhance the impact of their collections. Although largely neglected today by cultural heritage institutions, the so-called "lower senses" of which our sense of smell is a part, offer a powerful and direct entry to the emotions and memories of the public [25, pp. xiv, 3]. Museums can restore some of the materiality lost in the process of collection digitisation by including the sensory information in the metadata of historical documents and artefacts. This metadata would assist in the discovery of underlying sensory storylines, and bring new perspectives to the past. Recovering olfactory information in image datasets could thus provide a new way for individuals and communities to "make sense" of the collections.

This paper offers a roadmap towards an olfactory gaze for digital cultural heritage collections. The work we present here is part of the Odeuropa project, a research and innovation action in the Horizon 2020 programme. The goal of the Odeuropa project is to show that critically engaging our sense of smell and our olfactory heritage is an important and viable means for connecting and promoting Europe's tangible and intangible cultural heritage. In the following pages, we present our work in progress on olfactory heritage and

(a) Raising of Lazarus. Miniature. (1480-c. 1500). Bodleian Library, Oxford, MS. Douce 266, fol. 078a verso.

(b) Dieric Bouts, Christ in the House of Simon (1440s). Staatliche Museen, Berlin, inv. 533a.

sensory mining in digital art collections. First, we will describe the current state of the art, showing how olfactory information is traditionally missing or even omitted from digital art collection management systems. Then, a baseline research will be presented, which maps the gaps and biases in art thesauruses and iconographic classification systems. Next, we will present two connected solutions that we are currently developing in the Odeuropa project: a) a database with olfactory information related to historical artworks, aimed to enrich existing metadata to improve search solutions b) computer vision methodologies for sensory mining.

Finally, we will pitch a new idea: a nose-first odour wheel. When integrated into current digital collection interfaces, these scent wheels would encourage audiences to develop an olfactory gaze and offer new ways to discover the rich storylines of olfactory heritage within digital collections.

2 Olfactory Gaze: State of the Art

Figures 2a and 2b show two iconic fragrant depictions from the Bible. In the first scene, Lazarus is risen from the dead by Christ. Martha, the sister of Lazarus, expresses her concern about resurrecting him as he had been dead for four days: “he stinketh” (John 11:39). In the second scene, shortly thereafter, Christ revisits Bethany, where Mary, Lazarus’ other sister, washes his feet with costly spikenard oil, after which she dries his feet with her hair. The resurrected Lazarus also attends the feast (John 12:3). These stories are probably not recognized by most people for their olfactory qualities, yet this sensory knowledge brings new depth, and connects them to corresponding olfactory iconographies. The raising of Lazarus is not only a story about the power of Christ over death, and about faith in the last judgement, but it could be said that it is also a narrative about (overcoming) the stench of decay by divine intervention. The rich iconographic tradition of this scene also provides insight to the history of olfactory gestures, for example, how people coped with stench by pinching the

nose, or by covering the nose with an elbow, hand, sleeve, or other parts of their garments.

As mentioned above, the second scene of Mary anointing Christ's feet (figure 2b) introduces the history of spikenard, a precious aromatic oil derived from the root of a flower. Spikenard was used in a similar manner to myrrh, a resin extracted from a tree, and are both linked to the divine and held at high economic worth. They were traditionally linked to divinity because of their rich and strong, faintly sweet aromatic quality serving as a fragrant (or burnt) offering, or wordless prayer to God [18]. In this capacity these substances are affiliated with biblical figures such as Saint Joseph (who often carries a spikenard plant as an attribute), Mary Magdalene (who is also associated with anointing Christ's feet), the three Magi (who offer myrrh, frankincense and gold to the Christ child), the Myrrhbearers (who embalm Christ) and even the mythological character of Adonis (born from his mother Myrha, who was transformed into a myrrh tree that produces the resin).

All of these olfactory stories lay hidden behind the scenes, for none of the olfactory information we just highlighted is provided in the (meta)data of major digital art collections. The scenes are described in databases as "the raising of Lazarus" and "the anointing of Jesus", with no indication of the scents, their meaning, nor their associated olfactory gestures. It would take a trained **olfactory gaze** to identify, interpret and connect these kinds of scented scenes. But what do we understand by "olfactory gaze" and how could digital collections offer such a gaze to the public?

The term olfactory gaze was coined by art historian Caro Verbeek [48], but the method is in fact exercised by many scholars of olfaction ([18]; [7]; [27]; [49]). In the arts, the "gaze" refers to the act of seeing, starting from the premise that how we interpret the visual is culturally induced. For instance, the "male gaze" and "female gaze" are used to interpret art through a gendered perspective. The olfactory gaze refers to the act of analyzing images and texts with olfaction in mind, breaking away from a "scopic regime" or visual dominance, and thus revealing words, narratives, objects, scents and their related artefacts, which would have remained invisible from a purely visual perspective. Rereading canonical texts enhances this type of viewing and assessing of artworks. Primary sources such as the Bible and Ovid's *Metamorphoses* [1] or secondary sources such as James Hall's *Dictionary of Subjects and Symbols in Art* [17] are instrumental in acquiring information on olfactory cues in images and texts.

What is the current **state of the art** which can help us to further develop an olfactory gaze? The senses, which have traditionally received little attention from researchers, are now high on the academic agenda [40]. In the last two decades, a "sensorial revolution" has taken hold in the humanities and social sciences, which has shifted scholarly attention away from the visual and textual to the embodied and multi-sensory ([10]; [19]). This reframing was a reaction against both long-standing, traditional ocular-centric thinking, in which vision was the main sensory instrument of knowledge, and to the linguistic turn of the 1960s [20]. In the field of history, the "founding study" for this shift, Alain Corbin's *Le miasme et la jonquille/ The foul and the fragrant* (1982) [11], presented a grand narrative about the fundamental olfactory shift of the eighteenth and nineteenth centuries. In this period, Europe witnessed a paradoxical shift, with on the one hand Europeans becoming more sensitive to odour, and attempting to deodorise their environments, while on the other hand the sense of smell also began losing its importance as an instrument of knowledge ([11]; [45]).

More recent scholarship has focussed on describing the meaning of odours in particular places and times ([13]; [3]; [33]; [43]; [24]), including studies on how smell has signalled identity, community, and otherness in the past, including race and class ([40]; [44]). However, the focus on disgust in much of this scholarship has tended to emphasise the power of smell to

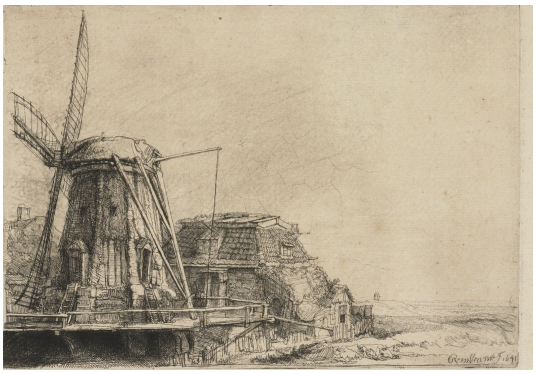

Figure 3 Rembrandt van Rijn, The Small Stinky Mill in Amsterdam (1641). Rijksmuseum, Amsterdam RP-P-1962-90

exclude rather than its role in forming and sustaining place, community, and inclusion. This could be one of the reasons for smell's current absence from many definitions of (in)tangible cultural heritage. Furthermore, the ephemeral and distributed nature of smell makes it difficult to find catalogued or indexed references to it in textual archives; while the number of references to smell in images has also been consistently underestimated [45]. Studies on smell in **art history** have also gained more ground [7]; [10]; [35]; [47]; [48]; [49]).

A new way to explore digital art collections is brought in by computer science. Advances in computer vision make it possible to analyse large amounts of visual data and to apply techniques of distant viewing, shifting the focus to broader contexts and enabling the application of quantitative methods [2]. Clustering visual data according to quantitatively defined categories may lead to insights that escape the close inspection of art historians. This has led to surprising results in a broad range of applications, e.g. in the context of compositional image structures [26] or the Warburgian Pathosformeln [22].[2]

It is the ambition of the Odeuropa project to advance the "sensory turn" and offer new perspectives for humanities research and the cultural heritage communities. Below, we will elaborate on how we aim to do this.

3 Searching for olfaction in the metadata of digital cultural heritage collections

Imagine you are a scholar interested in researching olfactory history and heritage. If you would use digital art collections as a source of information, what kind of knowledge would you gain? The answer lies in the currently limited metadata of digital collections which does not provide easy access to olfactory heritage and history. Many museum collections hold interesting olfactory objects and artworks presenting smell narratives, but in most cases the olfactory information is not made explicit in the metadata of the objects. When references to smell are presented in the metadata, it is often impossible to navigate from a single object to other related objects or scenes, due to a lack of overarching categories.

To explain the current situation, we have analysed the rich digital collections of Rijksstudio, Museum Digital, and Europeana. The Dutch Rijksstudio, which is the digital repository of

[2] However, although digital art history, and specifically computer vision for digital collections, are fast expanding fields, they have not yet had a lot of interest for the sensory gaze.

artworks from the Rijksmuseum, Amsterdam, consists of 715.643 items (d.d. March 2021). The German Museum Digital provides access to nearly 550.000 digital objects of around 700 German museums. Europeana collection provides access to over 50 million digitized items from over 3.500 European cultural heritage institutions which are divided into different thematic collections. We believed that the art and fashion collections would hold the most olfactory related results. More information might be found in museum collection management systems such as Adlib, which are generally not available to the public.

Search terms	Europeana (all)	Europeana (art)	Europeana (fashion)	Rijksstudio	Museum Digital	Iconclass
smell	1234	52	3	133	(Geruch) 30	11
scent	702	23	8	154	(Duft) 16	9
olfaction	97	0	0	0	(Geruchssinn) 45	0
stench	58	3	0	(stank) 16	(Gestank) 9	0
smoke	5080	118	24	195	(Rauch) 500	22
smoking	9336	1008	477	412	(rauchen) 103	22
incense	1833	213	8	266	(Weihrauch) 70	37
odour	534	19	0	12	0	65
malodour	2	0	0	0	0	0
aroma	2230	22	56	1	0	0
fragrance	179	17	5	7	-	1
perfume	1365	146	31	209	(Parfüm) 19	12
burnt offering	36	9	0	19	(Brandopfer) 111	6

Table 1 Search results for olfactory terms in diverse digital collections. #Hits. Search performed April 27, 2021.

Simple searches with obvious search terms such as “smell”, “stench”, “aroma”, “perfume”, or more expert terms like “olfaction”, “incense”, or “malodour” render interesting, but often meager results in the different datasets (table 1). The Europeana art collection, which holds 3.215.971 items, only renders 52 results for “smell”, 23 for “scent” and none for “olfaction”. The results of the fashion collection are even lower. In “Europeana all” smell has a higher representation (1.234 hits). Around 400 of those hits consist of samples of plants and animals from natural history collections, such as the Royal Botanical Gardens in Kew. “Smoking”, brings up results like pipes and cigarettes, but also many suit jackets. The Europeana collection is unstable, as we discovered while undertaking the research for this study that the number of results from the same searches fluctuated by the day.

While searching these databases, a trained olfactory researcher might think of more expert search terms, such as “civet” (a perfumed secretion from the civet cat), “musk” (a perfumed secretion from the musk deer), or “pomander” (fragranced jewellery), but how would a non expert find these categories? Many visitors may not even think about words like “olfaction” or “olfactory” as overarching terms. This problem could be solved if non-experts could be helped by the collection specialists, when the overarching category of smell was linked to these olfactory artefacts, odourants and other smell related terms.

Rijksstudio, has the potential to provide access to a wealth of information about historical art and sensory history. One can use English language search terms (used in the “Subject” field) or Dutch language terms (mostly used in the “Title” and “Description / Omschrijving” fields). Dutch terms render more results, but they also invite more irrelevant content. For example, “Geur*” (Smell*) not only displays paintings and engravings with allegories of the five senses and works with “Geur” in the title, it also brings up artworks by Geurt van Dijk (10), Geurt van Eck (9), P.A. Geurts (10) and Joris Geurts (2). Around 30% of the results

Search term	Entry in Adlib Rijksmuseum?
Geursthof (odorant)	no
Geur* (scent/smell)	no
Ruik* ((to) smell)	no
Olfac* (olfaction/olfactory)	no
Stank (stench)	no
Roken (smoking)	yes
Wierook* (frankincense/incense)	yes (Wieroksheepje, wierokvaat, wierokschaal, etc.)
Reuk* (sense of smell / scent)	yes (reukbal, reukdoos, reukfles, etc.)

Table 2 Search for smell terms in **Adlib - Rijksstudio**. The "*" behind general lexemes was used to allow for broader search results.

turned out to be unrelated to smell. The search for "roken" (to smoke) rendered over 70% of results irrelevant to smell: most of the objects found were "rokken" (skirts). In Rijksstudio, the open "Description" field provides cataloguers with the opportunity to mention specific smells, fragrant materials or smell related artefacts and narratives. For instance, searching for "stank" (stench) in Rijksstudio, we can find an engraving by Rembrandt van Rijn of a windmill. The title and subject categories do not present olfactory information, but the added description field tells us that the mill Rembrandt depicted is the Amsterdam leather mill, also known as the "kleine stinkmolen" ("the small stinky mill"). As indicated in the artwork's description on Rijksstudio, this name reflects the foul stench of urine which was used in the tanning of leather (figure 3). The "Description" and "Title" fields of the database are valuable, but unreliable. Most official titles of artworks do not highlight olfactory information, and based on these results, it seems that many collection specialists overlook the olfactory related cues in artworks.

The apparent limited results reveal that artworks and objects which have olfactory related content are not properly labeled or tagged with olfactory language and associations. These omissions and inconsistencies lead to limited search results for users who are not acquainted with more specific scent related language, and hence will end up with fewer results when searching for scent related art and artefacts.

Iconographic classification systems: Iconclass

Many digital art collections also make use of iconographic classification systems to order information. Iconclass is a multilingual (English, German, French, Italian, Finnish) iconographic classification system used by museums and other heritage institutions for the description and disclosure of images of works of art, book illustrations, reproductions and photographs [46]. Iconclass is one of the largest content classification systems within visual arts. Initially designed for historical imagery, it is now also used to create subject access to texts and to classify a wide range of images. Like the Dewey Decimal Classification system, Iconclass works with ten main divisions, which give entry to hierarchically ordered subdivisions. In 2021, Iconclass contained over 28,000 unique concepts (classification types) and an entry vocabulary of 14,000 keywords. Iconclass thus offers a rich pathway for structured searches in digital art collections.

The Iconclass codes are very useful for structured searches, moving beyond single word searches and the limits of language. When searching for "smell", the Iconclass code 31A33 ("Smell, smelling") results in 92 hits (both cases render various duplicates). Using Iconclass codes may help the researcher find a path of related classes. When searching for smell in the

Iconclass thesaurus, we are presented with the following concepts (table 3):

31A33	Smell, smelling (one of the five senses)
31A330	"Odorato" (Ripa)
31A331	Agreeable smell
31A332	Disagreeable, repellent smell
25H172	"Locus amoenus" motif: pleasant place with trees (taste), meadows (sight), spring or brook (feeling), singing birds (hearing) and flowers (smell)

Table 3 Smell concepts in Iconclass thesaurus

As has been observed before, Iconclass holds biases, as a result of cultural biases of historical artworks and of the Iconclass developers [8]. The class of smell as one of the five senses, and the allegorical "Odorato" (cf. "Odoratus") are sided by a classification of smells in "agreeable" and "disagreeable". This classification is problematic, as it is based on hedonic evaluation, or the categorisation based on a pleasant or unpleasant reaction. The experiences surrounding scents are culturally determined and based on context, and therefore fluctuating over time. We propose that the Iconclass codes should take period and cultural specific biases into consideration by avoiding the use of hedonic and subjective terms such as "agreeable" and "disagreeable".

Moreover, the Iconclass subclasses of "smell" are gendered, indicating a strong (art) historical connection between smell and women (table 4):

31AA330	"Odorato" (Ripa) - AA - female human figure
31AA33	smell, smelling (one of the five senses) - AA - female human figure
31AA331	agreeable smell - AA - female human figure
31AA332	disagreeable, repellent smell - AA - female human figure

Table 4 Iconclass subclasses of "smell"

While it is true that many historical paintings depict women in the act of smelling (mostly flowers) [6], the association of olfaction being solely feminine as an allegedly transhistorical phenomenon tells only half the story. Historical art also presents numerous men in the act of smelling, pinching their nose, using perfume, or using their nose as a professional instrument of knowledge (think about physicians, perfume makers, or hygiene officers). The gendered prejudices around olfaction manifest themselves in the metadata of Iconclass, where smell is retrospectively attributed to women, even in the case of genderless objects, such as pomanders and perfume bottles. "Using scents, perfumes, ointments, etc for women" (31A514AA) and "pomander - musk ball - AA - (for) women" (31AA51451) are subcategories specially dedicated to women. There are no equivalents for men. The overarching category "using scents, perfumes, ointments, etc" (31A514) is supposedly neutral.

In case of the "pomander for women", this is positioned in a hierarchy below the upper class "Implements - making toilet - AA (for) women" (31AA5145). This is even more problematic as it limits the use of pomanders to a strictly aesthetic means, when pomanders were multifunctional objects used within fashion, hygiene, and as amulets (good luck charms) [14]. The categorization by Iconclass thus demonstrates a bias where fragrances are associated with aesthetics or hedonics instead of being described as closely intertwined with the history of health, medicine, and religion, utilized by men and women alike. Furthermore, we could question why musk is singled out as an odorant in the label, "Pomander/ muskball" as pomanders contained different herbs and resins and substances of animal origin like ambergris

Figure 4 Caspar Luyken, Sacrifice of Noah after the Flood (1712). Rijksmuseum, Amsterdam, RP-P-OB-45.769.

(sperm whale) or civet (civet cat) [27]. Without a mention of these odorants in the case of pomanders, the researcher loses a trail, which could have led to other rich olfactory information and connections.

The most obvious bias in Iconclass is the ocular-centric based approach, which often disregards, misrepresents, or omits olfactory information. This, for instance, becomes apparent in the realm of religion.[3] In the Bible, various descriptions are given of burnt offerings (figure 4). In ancient history, burnt offerings were events of (combined) animal sacrifices and/or incense burning. In art both events share the iconography of ascending smoke [18, pp. 14–15]; [10]). In the case of incense burning, by heating fragrant resins (also called "per fumum" or through smoke), fragrant emanations rise to God [18, pp. 14–15]. However, when describing burnt offerings, Iconclass only references the offering of animals. Furthermore, the smoky event of animal sacrifice, known for its fragrant qualities (viz. Psalm 66:15: "I will offer unto thee burnt sacrifices of fatlings, with the incense / fragrant offering of rams"), is stripped of its olfactory information in Iconclass. When Noah performs a burnt offering ("Then Noah built an altar to the Lord and, taking some of all the clean animals and clean birds, he sacrificed burnt offerings on it", Genesis 8:20), the Iconclass code 71B343 just describes the scene in general as a "sacrifice". The same happens with the burnt offerings of Solomon (71I531).[4]

Iconclass could instead create a taxonomy in which these individual animal burnt offerings are connected with the broader Biblical infrastructure of burnt offerings (12A312 the altar of burnt offering, the brazen altar), and with the incense burning that mostly accompanied

[3] One example is Isaac smelling Jacob. Iconclass registers this event under 71C274 as "Isaac lying in bed blesses Jacob". Iconclass mentions goatskin but not Esau's coat that is "the smell of the field" (Genesis 27:27).

[4] Highlighting the inconsistencies of Iconclass cataloging, other Iconclass codes do refer to burnt offerings: 71L2513 (Manasseh sacrifices his own son as a burnt offering), 71E5272 (The Israelites offer burnt sacrifices on Mount Ebal), 71F2132 (Gideon and ten servants destroy the altar of Baal, cut down the grove near it, build an altar to God on the rock, take a bullock and offer a burnt sacrifice).

animal sacrifices (e.g. 12A311 the altar of incense, the golden altar). The taxonomy could also link to the odorants used in offerings. The Bible often specifically mentions frankincense or olibanum while Iconclass often uses the generic term "incense". This captures how olfactory information is often removed from metadata. The burnt offerings are just one of many examples. Our baseline research shows that digital collections and information management often overlook relevant sensory information. Expert knowledge would be required to restore this information, and to build a classification system in which these scenes can be linked through a structured taxonomy.

In order to overcome these biases and gaps, the Odeuropa project is developing a database for olfactory (art) historical information. On the basis of expert knowledge (literature of the history of smell, iconographic classification systems, digital collection searches, etc.), we are building a database divided into four classes: 1. **Olfactory objects** (odorous substances such as plants and foodstuffs, and olfactory artefacts such as tobacco pipes, perfume bottles ciboriums and pomanders), 2. **Olfactory gestures** (holding the nose, bringing odorants to the nose, or actions that produce a smell, such as urinating), 3. **Fragrant spaces** (built environments such as farms, offices and churches, and natural spaces such as forests and flower fields), 4. **Olfactory iconographies** (smell-related iconographies such as the Adoration of the Magi, and allegories of the sense of smell which include sniffing a rose, or changing a diaper). Where possible, we also added Iconclass codes to the entries. Seven months after the start of the Odeuropa project, the database consists of 354 entries (table 5). Of these 354 entries, we were able to trace Iconclass codes of 180 entries. In the next phase of the project, the database will be expanded with new entries, discovered through computer vision techniques, and archival and literature research.

	# Odeuropa database entries	Iconclass code
Odorants	175	55
Olfactory actions	33	22
Olfactory spaces	75	50
Olfactory iconographies	54	44

Table 5 Description of the Odeuropa Olfactory Art history Database (beta version): number of entries and number of entries with Iconclass code (April 2021).

4 Automatic extraction of olfactory information in artworks, using Computer vision techniques, Wordnet and Imagenet

Identifying visual references of olfactory phenomena in artworks is an important way to uncover how Europe may have smelled in the past and how smell was represented. The computer-vision team of the Odeuropa project works to create methods which would automatically extract these references from various large collections of European artworks by applying, modifying, and extending state-of-the-art object detection methods. In order to collect and extract olfactory references using computer recognition, it is necessary to first identify how smell is visually represented or depicted in historical artworks.

To provide an example of how this works, we used the print *Smell* (1581-1656) by Nicolaes de Bruyn, from the Rijksmusuem's collection (figure 1). In the sixteenth century, the pairing of a woman with a dog was used as a visual depiction or personification of the sense of smell [17, p.105]. Since object detection methods are able to identify the dog and the woman, this would seem like an effective system to use for sensory mining. However, there are

certain challenges which come with this detection. Firstly, not all pairings of people or women with dogs are olfactory. For example in other periods, a dog on the lap or feet of a woman may represent fidelity [17, p.105], as seen in Jan van Eyck's *Arnolfini Portrait* (1434). This presents us with the challenge of distinguishing when a dog is or is not an indication of olfaction. A second challenge is that computer recognition does not detect the olfactory gesture of the woman smelling the flowers. This poses further challenges for detecting olfactory elements in paintings.

Similar challenges arise when detecting olfactory narratives in Biblical scenes, for instance with the Sacrifice of Noah (Genesis 8:20), discussed before. The print, *Sacrifice of Noah after the Flood* by Casper Luyken (figure 4), shows Noah creating a burnt offering of animals, combined with the usual "rainbow of the covenant" in the background. While the people and animals are easily detected, the cloud of smoke is not, hence overlooking the olfactory element of the artwork. These types of olfactory narratives reveal more limitations of existing object detectors. Object detection systems are limited to the data with which they have been trained. Firstly, since the detectors are trained with photographic data, their effectiveness decreases when applied to images with an artistic style, such as historical paintings and prints. Secondly, as computer vision research prioritized humans and animals, objects like smoke are either underrepresented or not at all part of the detector's training data.

In order to tackle these issues, the Odeuropa project will adapt existing techniques to improve the detection abilities on artistic image domains. Various techniques enable models trained on the photographic domain to adapt to a different domain. In **transfer learning**, a detection system is pre-trained on large-scale photographic datasets before fine-tuning it on a smaller dataset in the target domain [32]. **Style transfer** means transferring labelled training data to the target domain before training [38]. Finally, **self-supervised learning** entails training a system to perform an unsupervised pretext task like solving jigsaw puzzles in the target domain before training the actual task of object detection. Prior to the intended application, the system can thus learn attributes about the target domain without need for large amounts of labeled data [23].

Detecting predefined odorous entities is a challenge that can presumably be solved by the application, combination and modification of these methods. Another challenge is that many of the olfactory objects we identified are too specific to be found by state-of-the-art object detection methods. We therefore follow an approach similar to [36] or [37] and order the identified objects according to a hierarchy following the structure of the lexical database WordNet [29]. Each object label then carries information about parent terms as well. A depiction of a lily for example can then not only be correctly recognised as a lily, but also as a bulbous plant, a flower, or a living object. Via a suitable weighing of the label specificity we thus enable the system to detect more abstract categories where the concrete object is not recognisable. This approach has the additional advantage that ImageNet [39], a large dataset of photos annotated with object labels that uses WordNet concepts, can be used for pre-training our models.

In many cases, the invisible references to olfaction might not be as easily detectable as with objects that emit a strong smell. Iconographic allusions, or reactions to smell are examples of more complex olfactory references that require semantic context knowledge to be recognised. We plan to combine and extend our object detection method with more advanced techniques like analyzing the co-occurence of detected objects and their relative position, estimation of poses of depicted persons, or the classification of iconographies to enable the recognition of olfactory cues that are not evident on the first sight.

These ambitions reveal the need for a pragmatic taxonomy of olfactory phenomena that

serves as a tool for object detection. The top level categories are defined by the techniques that can be applied to detect the respective phenomena (see figure 6 for a draft version). Lower level categories depend on the requirement of the specific detection technique - in the case of odorous objects: a hierarchy based on WordNet.

5 Advancing the Olfactory Gaze with Odour Wheels

Europeana and Rijksstudio offer the opportunity to browse their collections on the basis of colour.[5] Under each object, a slide of its colours is presented. Researchers can click on one of the colour schemes and find related objects, which allows users to create surprising connections that they might not have come up with themselves, adding the possibility of new layers of meaning utilization of the collection.[6]

Inspired by the colour schemes, we would propose to enrich digital art collections with **odour wheels**. Odour wheels are visual representations of smell quality containing sensory information such as smell "families" (floral, woody, etc.) and smell descriptors (such as fresh, musty, pungent); some odour wheels also display chemical compounds associated with each descriptor. Wheels like these are widely used in the flavour and fragrance industries ([30]; [41]). In addition, odour wheels have been produced to characterise other types of smells, such as urine in the sixteenth century [12], urban smells [34], and compost and water [42]. While their use as a documentation tool is popular, the methodology for developing an odour wheel is not standardised, nor is their function. Cecilia Bembibre [5] identified three main categories for wheels depending on their approach: (1) focused on sensory aspects, (2) combining sensory and chemical descriptors and (3) records of a personal olfactory experience. The wheels in the first category organise olfactory information hierarchically, usually going with a general ("families") inner ring which encompass large olfactory traits towards more detailed subcategories and then odour descriptors. These categories group smells with similar sensory qualities. The second group is often used in the identification of malodours and focuses on establishing connections between the chemicals responsible for certain odours (e.g. acetic acid) and the way they are described sensorily (e.g. sour, vinegary), often also grouping scents according to sources (e.g. "industrial"). Finally, the third group comprises examples where an odour wheel is used for documentation purposes only, such as the one resulting from Rachael Morrison's sniffing of the book collection in the Museum of Modern Art (MoMA) Library in New York [16].

This diversity of methodological approaches is often seen as a limitation of the wheels as a documentation and educational tool, especially when coupled with non-transparent choices such as the criteria for the size of odour categories that can lead to misrepresentations of the olfactory qualities [15]. Another perceived limitation of the wheels is the fact that the circle shape might be interpreted as a complete representation and therefore discourage innovation [31]. However, there is also an effort from many researchers and industry professionals to present the wheels as a dynamic tool that invites further contribution.

We acknowledge the limitations of the wheels but, given the innovative application proposed in this paper, we estimate it will be a helpful tool. The art historical odour wheel we propose is not only meant for documentation purposes, but to enable digital scent-based

[5] `https://pro.europeana.eu/page/search`

[6] Colour may seem disconnected from context, but certain hues are indicative of industrial developments resulting in new colours, or have symbolic meaning in certain eras, such as the blue pigment ultramarine, indicating "hyperdulia" or sanctity [4, pp. 81–85].

queries. The wheel is visually and conceptually familiar and open to improvement, while effectively anchoring the olfactory gaze concept for its unique capacity. Our approach is quite innovative in yet another way because odour wheels usually apply to singular objects (books, coffee), domains (foodstuffs) or to complex scentscapes such as cities [28], and rarely to entire scholarly disciplines.

We propose a nose-first art historical odour wheel[7], which is based on the Odeuropa Olfactory Art History Database, as described before. At this moment, the database consists of 354 entries in 5 classes, with references to Iconclass codes (where possible), and descriptions of the (in)visible odorants. These odorants were categorized into scent families, for which we used: 1) perfume industry odour classifications, 2) the categories "industrial" and "gourmand" from urban scent classifications [28], 3) classifications used in chemistry and food, 4) we added a category "sour/ acid" to classify odorants such as vinegar and vomit. A team of olfactory experts set to work, categorizing for instance frankincense and myrrh as "resinous", and bread and milk as "gourmand/ food". Ambergris, civet, musk (animal materials) and horses were grouped into the parent term "animalistic". Some olfactory sources ended up in two different categories. "Cows" are both "animalistic" and "rural", a class in which forests and farms find their place.[8] The nose-first odour wheel (figure 5) starts from the scent families, connected to odorants in the second ring, which leads to the artworks and artefacts and their Iconclass codes. This model reveals surprising similarities and connections between concepts that are quite dissimilar from an ocularcentric point of view. When taking this perspective, we can compute an olfactory distance between seemingly unrelated depictions and, metaphorically speaking, let viewers of digital collections query images with their noses. Since the scent wheel entails information about the olfactory composition of visual smell references, we can decompose every detected phenomenon into its olfactory components. Based on this composition and the associated smell families, an olfactory similarity between two concepts can be quantified. We plan to use this novel concept of an olfactory distance to make the olfactory gaze accessible when looking at digital collections of art. A viewer could for example regard an artwork and get recommendations for artworks that smell similar, or specifically look for artworks that depict objects that smell, for example the countryside (rural). Thinking and searching with an olfactory gaze has led the research team to find formerly overlooked olfactory iconographies such as "Jonah in the whale," alluding to the animal's visceral smell, "Descent into Limbo", evoking the scent of sulphur and cadaverine, and "Napoleon", who was known for his daily and ample use of Eau de Cologne. In various cases, several scents are connected to one individual story.

An exciting addition would be to expand this wheel with chemical compounds associated with the odour descriptors. This would enable professionals to reconstruct historical scentscapes and to use scents in museums for educational purposes. And finally: the wheel we present here is static. The next improvement is to make it more dynamic, for instance by creating a zoomable wheel, and by linking the wheel categories directly to the relevant scenes in the artworks, by using computer vision techniques.

[7] The term "nose-first" was popularized by smell mapper Kate Mclean [28].

[8] We want to emphasize that this classification task is a work in progress, which brings many challenges. For instance, the scent family "malodorous" is problematic since hedonic evaluation is often culturally determined.

6 Conclusion

Digital cultural heritage collections present a wealth of information about the sensory world of the past. However, it is currently difficult to extract olfactory information from the metadata of these collections. In this paper, we have described the current situation, and presented a series of solutions to overcome the ocular bias of art collections which would help visitors and researchers to develop an olfactory gaze. Our solution entails the combination of computer science techniques with expert (art) historical and olfactory heritage knowledge. The Odeuropa project is developing an Olfactory Art history Database, with a rich taxonomy of olfactory phenomena, following the structure of the lexical database WordNet. The database informs the automatic object detection methods employed by the computer vision team. Furthermore, it informs a nose-first odour wheel (with (in)visible cues to olfaction) which digital heritage institutes could use to improve discoverability and heighten the impact of their digital collections.

The nose-first odour wheel can inform a broad audience about the olfactory past in a playful manner and allows users to find unexpected connections between artworks. At the same time, the collected olfactory metadata enables computer vision experts to teach the computer how to recognize olfactory scenes and objects, leading to an even more vast and versatile overview of olfactory history.

The act of smelling should not be overlooked as a strategy for knowledge gathering. With the Odeuropa-team and affiliated partners, we are planning to organize exhibitions and tours with an olfactory gaze in museums of visual arts. By presenting historically informed scents for a nose-first approach, visitors can inhale scents while looking at artworks. The nose-first approach will thus become even more tangible.

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A Art Historical Odour Wheel & Taxonomy Visualizations

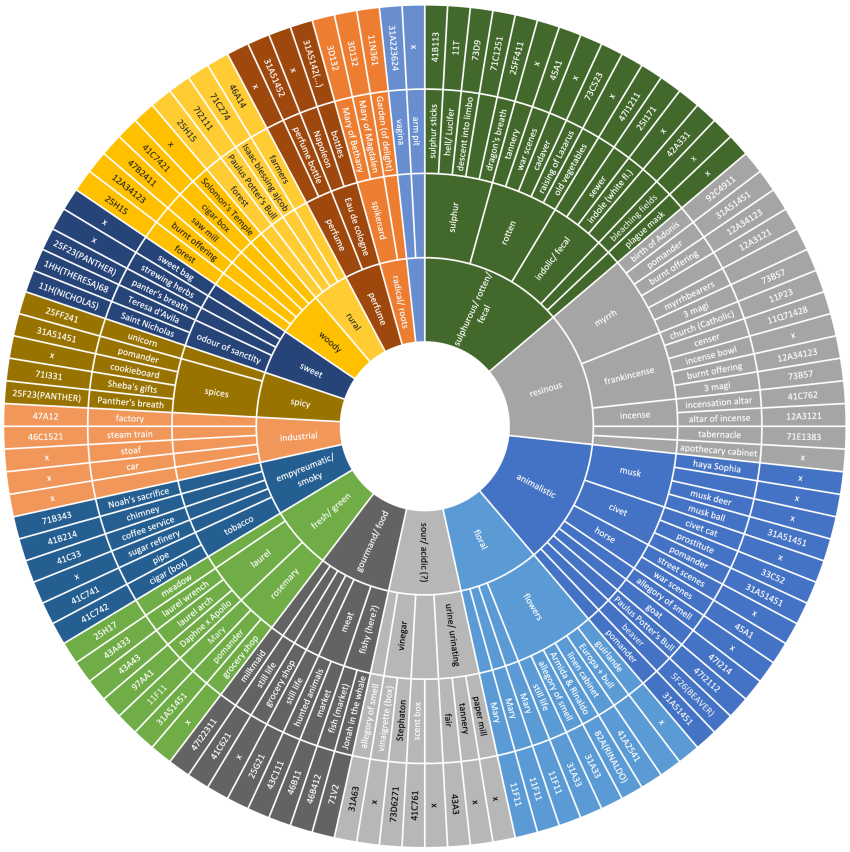

Figure 5 The Odeuropa "Nose-first art historical odour wheel" starting from scent families in the first ring, connected to odorants in the second ring, and then to artworks and artefacts around that, ending with an outer ring with Iconclass codes. Please note that the colours of the wheel are not specifically related to the content.

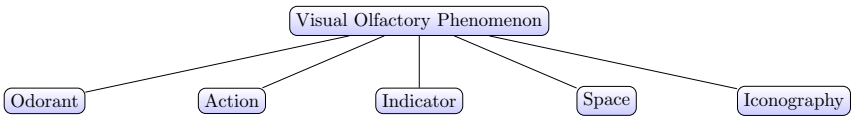

Figure 6 Top level categories for a pragmatic taxonomy for computer vision extraction of olfactory information from digital art collections (draft).