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Towards Equitable Representations of Ageing: Evaluation of Gender, Territories, Aids and Artificial Intelligence

Vanessa Zorrilla-Muñoz [1,2,*], Daniela Luz Moyano [2,3], Carolina Marcos Carvajal [4] and María Silveria Agulló-Tomás [2,4]

[1] Bioengineering Institute, Miguel Hernandez University, Elche, 03202 Alicante, Spain
[2] University Institute on Gender Studies, University Carlos III of Madrid, Getafe, 28903 Madrid, Spain; dmoyano@inst.uc3m.es (D.L.M.); msat@polsoc.uc3m.es (M.S.A.-T.)
[3] Health Science Department, National University of La Matanza, San Justo, Buenos Aires B1714, Argentina
[4] Social Analysis Department, University Carlos III of Madrid, Getafe, 28903 Madrid, Spain; 100453201@alumnos.uc3m.es
* Correspondence: vzorrilla@umh.es

Abstract: There are few studies on the representation of older people regarding aids and assistive devices and even fewer that incorporate more inclusive views (gender, emotions, anti-ageist, territorial or land approach) as well as virtual or land ethnography or artificial intelligence. The general objective was to evaluate digital images of aids and assistive aids in the older population, from the perspectives mentioned above. Method. A descriptive and cross-sectional study that searched, observed and analyzed images. An evaluation of intentionally selected images from Freepik, Pixabay, Storyblocks, Splitshire, Gratisography and ArtGPT, included in an original database constructured by several authors of this article, was carried out in the context of the ENCAGEn-CM project (2020–2023, financed by the CAM and FSE). This base was updated and expanded in October and November 2023. In addition, an image generation process was carried out using artificial intelligence, and this was also part of the analysis (ArtGPT). Finally, algorithms were used to solve and retrain with the images. Results. Of the total final images included in the expanded database until November 2023 (n = 427), only a third (28.3%, 121/427) included the aids and assistive aids label. Representations of mixed groups predominated (38.8%) and, to a lesser extent, those of women. A large proportion of the devices were 'glasses' (74.6%) and the 'use of a cane' (14.9%). To a lesser extent, 'wheelchairs' (4.4%) or 'hearing aids' (0.9%) and the presence of more than one device (simultaneously) (5.3%) were noted. The main emotions represented were 'joy' (45.6%) and 'emotion not recognized' (45.6%), with, to a lesser extent, 'sadness' (3.5%), 'surprise' (4.4%) and 'anger' (0.9%). Differences by sex were found in the represented emotions linked to aids and assistive aids. The representation of images of the built environment predominated significantly (70.2%), and it was observed that older women were less represented in natural environments than men. Based on the previous findings, a method is proposed to address stereotypes in images of older individuals. It involves identifying common stereotypical features, like glasses and hospital settings, using deep learning and quantum computing techniques. A convolutional neural network identifies and suppresses these elements, followed by the use of quantum algorithms to manipulate features. This systematic approach aims to mitigate biases and enhance the accuracy in representing older people in digital imagery. Conclusion. A limited proportion of images of assistive devices and older people were observed. Furthermore, among them, the lower representation of images of women in a built environment was confirmed, and the expressions of emotions were limited to only three basic ones (joy, sadness and surprise). In these evaluated digital images, the collective imagination of older people continues to be limited to a few spaces/contexts and emotions and is stereotyped regarding the same variables (sex, age, environment). Technology often overlooks innovative support tools for older adults, and AI struggles in accurately depicting emotions and environments in digital images. There is a pressing need for thorough pretraining analysis and ethical considerations to address these challenges and ensure more accurate and inclusive representations of older persons in digital media.

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1. Introduction

According to the latest World Population Prospects report, it is estimated there were 771 million people aged 65 or over worldwide in 2022. Moreover, the proportion of the world population in this age range will increase from 10% in 2022 to 16% in 2050 [1], which constitutes both a social success and a future challenge for current policies. Moreover, this demographic change and the factors contributing to it require attention in terms of developing public and social policy within this paradigm. How can we maintain healthy and active lifestyles for people during the ageing process? This continues to be one of the basic pillars in the development of public and social policy [2] for the older population with the maximum quality of life (QoL) and for society. Moreover, there are variations between continents, but, in terms of life expectancy, older women globally outnumber men in almost all populations [1], which is impacting social roles and policies, leading to a more inclusive vision with a gender and anti-ageist perspective. The factors that have mainly contributed to this demographic change and healthy ageing are progress in research in health sciences and biotechnology; greater knowledge of diseases and the drugs and therapies used to treat them; and the latest advances in technology and health devices. However, it should not be ignored that older women continue to be largely forgotten in terms of the roles and stereotypes that are common in this population group. This is mainly because they represent a social group with biased roles in caring for family members, and, because of technology, there is still an incipient digital divide in those who are older or very old. This bias remains latent in society.

In the context of technology, there are hundreds of devices and products focused on improving the QoL and well-being of people. However, many of these products present significant difficulty for older people—on the one hand, in relation to their cost–benefit ratio, and, on the other, in terms of accessibility and usability. This is in addition to the incipient digital divide within the older and very old population. For these reasons, even today, common aids and assistive devices usually cover a wide range of devices and tools designed to assist individuals in various aspects of daily living, mobility and health management—for example, walking sticks, wheelchairs, glasses and earphones. These types of aids are a focus point in public policy guidelines, since they can provide improvements in different QoL dimensions [3], which should be evaluated from a comprehensive, accessible, inclusive and intergenerational perspective. Therefore, new and emerging technologies that enhance ageing are designed mainly for activities of daily living, personal health or safety, mobility, communication and physical activity, which can facilitate independence in the home [4].

However, the use of the phrase 'health support technology' is often confused with the use of mobile phones and apps, which do not always effectively compensate for or alleviate illnesses or disabilities. This confusion can lead to unrealistic expectations about the capabilities of such technologies. Moreover, recent advancements in artificial intelligence (AI) have expanded its application in various fields. AI is now used to generate algorithms for aids and assistive devices, as well as to create chatbots designed to assist individuals and generative AI models that provide information about the ageing process. While these technologies may not always have a direct focus on health, they significantly influence health representation and can contribute to stereotyping [5]. For instance, AI-driven tools might inadvertently reinforce negative stereotypes about ageing by portraying older adults in a limited or negative light. This can shape public perception and contribute to a more negative collective imagination about ageing and older persons. Addressing these issues requires a careful, inclusive approach to designing and implementing health support technologies, ensuring that they promote positive and accurate representations of ageing and support the diverse needs of older adults.

Specifically, the way in which older people and their environment are represented through social images constitutes a central axis in reflections on old age and impacts the formation of stereotypes and generalized discrimination against older people. This representation is crucial because it shapes societal perceptions and attitudes towards older adults. When media and social images predominantly depict older individuals as frail, dependent and disengaged from society, these portrayals reinforce negative stereotypes and contribute to ageist attitudes. Such stereotypes can lead to generalized discrimination, marginalizing older adults and affecting their access to opportunities and resources.

Furthermore, age discrimination is a psychosocial problem that negatively impacts the health and well-being of older people (see [6], among other studies). Research has shown that experiencing ageism can lead to increased stress, reduced self-esteem and poorer mental and physical health outcomes. Ageist attitudes and stereotypes are pervasive across various media, with social networks being particularly influential. Social media platforms often amplify these negative portrayals, presenting older people as a homogeneous, vulnerable and powerless group [7,8]. This widespread stereotyping fosters an environment where ageist discourses thrive, further entrenching discriminatory attitudes and behaviors towards older adults.

This stereotyping not only shapes public perception but also influences policy and social attitudes towards older adults. Therefore, addressing these issues requires a careful, inclusive approach to designing and implementing technologies [5]. These technologies should promote positive and accurate representations of ageing and support the diverse needs of older adults, ensuring that they are seen as capable, diverse and valuable members of society. Furthermore, the intersection of gender perspectives with images and technologies plays a crucial role in shaping these representations. AI technologies, for instance, increasingly influence how older women are portrayed in digital media.

From a gender/sex perspective in older people, such as concepts linked to identity and how they are represented [5,9], there are antecedents based on data from digital images that have made it possible to study the presence of stereotypical images of old age with the greater presence of women [5]. These findings underscore the importance of examining how older women are depicted and the impact of these portrayals on societal perceptions and gender-based stereotypes.

The imbalance that appears in the activities attributed to men and women is notable, where women continue to appear within stereotyped roles in indoor spaces, carrying out care activities, while men carry out leisure activities in open spaces and are visible outside (see [5], among other studies). A recent review has shown the important gaps in knowledge about the representation of older people in the digital world in terms of love and sexuality, and diversity has rarely been addressed [10]. It is suggested to explore the terminology from a classic perspective, through collective or social imagination [11,12], with a positive representation of, for example, gender and older people. Although this study does not focus on exposure to social networks, there is literature on the population of older people in which the gender inequalities related to them are shown. For example, stereotypical representations and the invisibility of older people according to gender have been observed in Edström's study, which analyzes the media with the greatest presence in three different decades (1994, 2004 and 2014), indicating that men and women become almost invisible as they age, being more pronounced in older women [13]. Recently, in the case of social networks and digital platforms, discrimination against older people has also been detected in previous studies [14,15].

How older people are represented and the emotions that they express is a crucial basis on which to understand the psychosocial dimension of ageing, which has been identified by different authors, classic and recent, from the field of social psychology [16,17] with links to gender [18]. Here, significant numbers of images had no emotions represented, and, to a lesser extent, the emotions detected were sadness, surprise and anger [5]. It was also observed that there was physical contact and relational gestures in the representation of such people and the emotional states of older people [5].

The representation of older people and gender in images within a specific environment/space is of vital importance, since ageism is most manifested through the invisibility of old age, both in family and social contexts, as well as in other areas, such as nursing homes and households [19]. Furthermore, studies have shown that older people prefer their typical environments, but, when their care needs increase, they consent to be transferred to nursing homes [19] with aids and assistive aids. In this context, there is not much similar research available, with some exceptions [5,14,15,19,20] that investigate the representation of older people with health support technologies and health devices and incorporate inclusive perspectives—such as the gender, space and age approach from virtual ethnography and AI [21–23]. Moreover, digital images of older people often carry negative connotations, characterized by minimal diversity and a lack of emphasis on the positive aspects of ageing. This tendency is particularly relevant in media and advertising contexts, where depictions of old age tend to focus on negative stereotypes and aspects associated with the loss of physical and cognitive abilities [15]. This lack of diversity and the prevalence of negative representations can have a significant impact on the public perception of ageing and on the self-esteem of older persons. This means that digital images representing older people exhibit bias in aspects related to demographic shifts, disparities and equity. The latter is linked to the concepts of 'equity' and 'technology', implying an inclusive and intersectional approach in the application of technology analysis (see Figure 1).

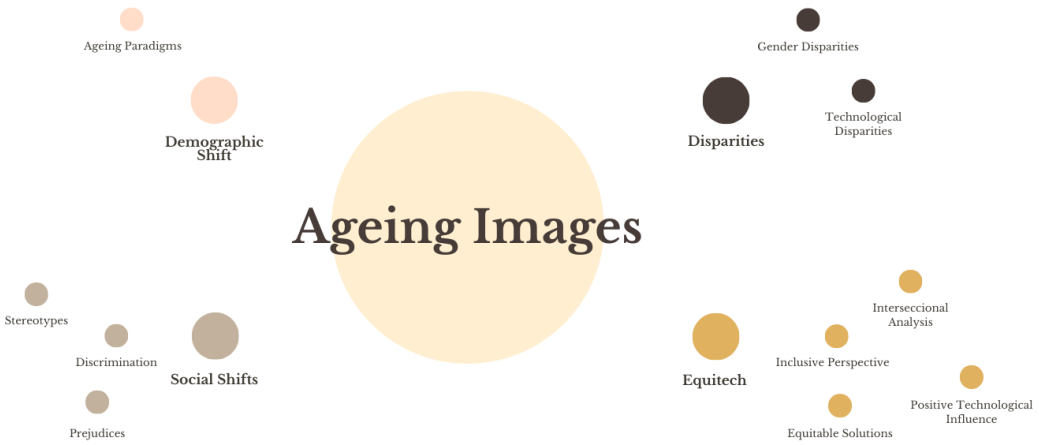

Figure 1. Representation of concepts used to evaluate ageing images. Note: own figure.

The main objective of this study is to evaluate digital images of aids and assistive devices in the older population, from the perspectives of gender, age and location, as well as from AI. It is expected that digital representations of aids and assistive devices in the older population reflect gender and age stereotypes and that their use and accessibility vary according to the geographical location. Regarding the 'age perspective', this study specifically examines how different age groups within the older population (e.g., those in their 60s, 70s, 80s, etc.) may be portrayed differently in digital images and how these representations can reinforce or challenge existing age-based stereotypes. Regarding 'location', the research analyzes how the availability, design and depiction of aids and assistive devices vary across different geographical regions, highlighting the disparities that may exist between urban and rural areas or across different countries. Additionally, it is proposed that AI may provide new perspectives and approaches in the analysis of these images, thus contributing to a deeper understanding of the representations and needs of the older population in relation to emerging technologies.

This study is imperative due to the significant demographic shift towards an ageing population worldwide. With the number of individuals aged 65 and above projected to increase substantially by 2050, there is a pressing need to address the challenges and opportunities associated with ageing. Furthermore, the gender disparities in life expectancy and societal roles underscore the importance of adopting a more inclusive perspective that

considers the unique experiences and needs of older women. Additionally, the influence of technology, including both aids and assistive devices and emerging AI applications, on the lives of older adults cannot be overstated. However, the current landscape of technological development often overlooks the diverse needs of older individuals, perpetuating ageist stereotypes and limiting their access to beneficial resources. Therefore, a comprehensive analysis of digital images of aids and assistive devices, considering gender, age, location and AI perspectives, is essential to promote a more inclusive and accurate representation of ageing and to address the evolving needs of older populations in the digital age. By exploring these dimensions, this study aims to shed light on the existing disparities and pave the way for more equitable and effective technological solutions tailored to the diverse needs of older adults.

2. Materials and Methods

This section comprises three parts: the study design and criteria for data collection; the method; and sampling.

2.1. Study Design and Criteria for Data Collection

This descriptive and cross-sectional study was carried out from a virtual ethnography approach [21–23], based on digital images, and the dimensions and categories were explored from a gender, spatial and anti-ageing perspective, linked exclusively to aids and assistive aids [5,9,24]. This work was designed as an ad hoc study within the framework of the ENCAGEn-CM program (2020–2023) [25] to promote a positive image of old age and ageing and combat ageism.

The search and inclusion criteria used to define the analysis database were based on variables that were related to gender/sex, age, representations of images in the environment, the presence of aids and assistive devices and emotions. They were labeled according to sex, i.e., 'man' and 'woman', with a combination of groups of people where at least one man and one woman appeared or multiple people of different sexes appeared. It was also noted when the sex was not recognized. If there were more than two people of different genders/sexes in the same image, the category of 'mixed group' was assigned; when there was an image of two people, one older and one younger, the sex was recorded for both people. The inclusion criteria and a brief description are given in Table 1.

Table 1. Inclusion criteria used to select images and representations of older people and their descriptions.

Criterion	Description
Representations of the environments of older people within different spaces	The definition of the natural and built environment was taken and the categories reported in the previous literature were adapted [26,27]. Within the built environment, specific categories were defined (residential, commercial, industrial, recreational, public services, transportation, green space with human intervention, work, others), as well as for the natural environment (agricultural areas, green areas without human intervention, and aquatic spaces). In the natural dimension, meteorological data categories (sunny, cloudy, rainy, windy) were also investigated. In all cases, the category of 'not recognized' was also added.
Presence of types of aids and assistive devices	Categories related to the use of aids linked to technology were selected from 'The Survey of Health, Aging and Retirement in Europe' (SHARE). This is an international and interdisciplinary project, with the application of rigorous common procedures and protocols [28]. This variable was applied only to older people represented in the images. When two older people who had different devices were found in the same image, both or a single person were recorded, but, in the presence of more than one device, it was recorded as a combined category. The categories from the aforementioned survey were based on the following: cane, Zimmer frame/walker, manual wheelchair, electric wheelchair, stroller/scooter, special eating utensils, personal alarm, bars/grips/rails, toilet seat (raised), pads for urinary incontinence, robots, tablets, mobile phones, electric scooters. There was also the possibility for emerging categories, such as glasses or hearing aids, or combined categories, such as canes and glasses or canes and manual wheelchairs.

Table 1. *Cont.*

Criterion	Description
Emotions	Basic emotions were selected and emerging categories were possible. When the emotion could not be identified precisely, the category of 'not recognized' was assigned (for example, when a mask was worn). In the case of identifying more than one person in an image who shared the same emotion, it was recorded as one; if there were different emotions in each person but only one had a support device, the emotion linked to said device was recorded. When different emotions were perceived with the presence of devices, only in this case was it recorded as a combined emotion category. The categories of emotions that were included to be explored were the same as those followed in the previous study [5] and the previous scientific literature [16–18], and they were anger, joy, surprise, disgust, sadness and fear and an additional category of 'not recognized'.

2.2. Method

The study consisted of two stages. Stage 1 started from an original database generated by several authors of this work [5] in the context of the ENCAGEn-CM program [25] until February 2022. For this work, the database was expanded and updated until November 2023 with the inclusion of images collected in different digital repositories. Open-access databases were considered: Canva, Freepik, Gratisography, OpenPhoto, Pexel, Pinterest, Pixabay, SplitShire, Storyblocks, Unsplash and Envato. Moreover, images were generated through artificial intelligence (AI). We used the free program ArtGPT.

2.2.1. Data Collection

Overall, until November 2023, all digital images that presented any element related to age or older persons were added and other types of media, such as illustrations or videos, were excluded. A subsample was intentionally selected in which some elements linked to aids and assistive devices had been detected, which, in this work, were the central units of analysis. It should be noted that the data collection was based on free and open-access websites, i.e., those that allowed images to be viewed and downloaded and that were free of rights (Creative Commons).

For the image search, a systematic process was implemented where keywords in English and Spanish were used to generate the searches. They were the following: 'personas mayores', 'vejez', 'edadismo', 'tercera edad', 'anciano' and 'anciana', 'jubilado' and 'jubilada', 'viejo' and 'vieja', 'edad', 'envejecimiento', 'elderly, 'ageism', and 'retired people'. The same criteria as for the original database search were used [5].

The selected images were downloaded and archived in secure folders, with the purpose of mitigating the 'ephemeral' process and the risk of obtaining information that had circulated through digital environments. Moreover, the systematization of these images was carried out in a database designed for this purpose. Corresponding links and other information related to metadata and descriptive information were included.

In addition, during this process, the analysis of the individually selected images was implemented. The previously defined categories were coded through the manual technique and then analyzed quantitatively. In this classification and coding process, visual elements, images, expressions and context, among other elements, were selected.

The inter-coder reliability measure for 'emotions' was Cohen's kappa coefficient. This coefficient is commonly used to assess the degree of agreement between two or more coders when categorizing or classifying data, such as the emotions portrayed in images. Cohen's kappa coefficient helps to determine whether there is significant agreement beyond chance agreement among the coders, thus providing a measure of the reliability of the collected data. The Cohen's kappa results are also included with the results of the emotions.

For example, Figure 2 provides an example of the dataset used and shows an older woman in the foreground, in a wheelchair, with a non-recognized emotion. It is worth noting that we focused on basic and primary emotions (4, 6 or 8, according to different authors). However, if we had used secondary or advanced ones, the list would have been expanded to dozens (different numbers depending on the authors consulted). For example,

we could have included calm or tranquility (or a lack of expression, depending on how it is interpreted), and we could have assigned this to many of the images of older people. The lack of expressiveness and calmness is sometimes difficult to differentiate with only a still image. This needs to be investigated further (e.g., evaluation of videos or audiovisual media). However, this was beyond the main study's objective, which focused on still images, and remains a challenge.

Figure 2. Image of an older woman with a wheelchair in an environment shared with other people. Source: https://lc.cx/xVIuxv. Accessed on 12 August 2024.

In the case of images generated by AI, the process was carried out by a researcher trained on the ArtGPT platform during the month of November 2023, and the procedure followed the introduction of keywords of interest related to older people, gender, emotions and support devices, to generate different tests. These keywords were 'older people', 'older women', 'older men', 'older people and happiness', 'older people and quality of life', 'older people and joy', 'older people and fear, 'older people and sadness' and 'older people and technologies', among others.

Different search combinations were implemented with the aforementioned terms and it was observed that the GPT generated six images with each one (in total, 22 intersections were generated, resulting in 132 images, in two phases or batches). Several tests were carried out and in no case were they repeated.

The final combinations, which gave rise to the 10 images that were included in the database for analysis, were generated from the following 5 intersections:

- Aids and assistive devices and older people and emotions;
- Aids and assistive devices and older people and emotions/joy;
- Aids and assistive devices, technologies and older people and emotions/sadness;
- Aids and assistive devices and older people and emotions/fear;
- Aids and assistive devices and older people and emotions/anger.

To report the results, the two images that appeared first were selected (of the 5 generated by each intersection, 10 images from the previous intersections), except when the image appeared distorted. With this, the combination of the terms used was applied to obtain images generated by AI. For each combination, AI generated a total of six images, and, from these intersections, they included aids and assistive devices and older people and emotions (null or joy/sadness/fear/anger or annoyance).

During the fieldwork for this study, each search combination consistently generated 6 images, regardless of the number of variables introduced. Therefore, although a total of 30 images was produced, only the first two images from each combination were selected, resulting in a total of 10 images evaluated for the five final intersections mentioned.

The images generated through AI were obtained using two email accounts, since a maximum number of images was allowed per account. It should be noted that there was a limit to the number of images that could be accessed free of charge. In the case of exceeding this number, the AI requests a paid subscription.

From each combination of keywords, only the first two output images (of the initial six) were included since they were the ones that were most relevant to this study, and the distorted images were not included.

Another aspect to highlight is that while general criteria were used for the images from the digital repositories and when reproducing the searches of a previous study [5], more specific criteria (as mentioned above) were included in the case of AI-generated images.

2.2.2. Data Analysis

To reduce information bias, all images were reviewed at least twice by two independent researchers [22] and discrepancies were reviewed in virtual meetings within the working group.

The analysis of the final database was carried out through a descriptive analysis (absolute and relative frequencies), and a narrative analysis of the results was included to generate some initial ideas about the image generation process using AI. Images were selected to illustrate some of the dimensions of the analysis.

This study was based on an analysis of freely available digital images in web repositories, so it did not require evaluation by an ethics committee.

The total number of images included in the secondary database was n = 427 (300 initial + 117 new from the selected repositories + 10 generated by AI).

Finally, 121 images were evaluated, amounting to 28.3% of the total of 427, consisting of those where the image identified or referred to aids and assistive devices (n = 121 images) (Figure 3). The study included a descriptive statistical analysis of the images, where the results were expressed as the frequency of the number of images and their percentages.

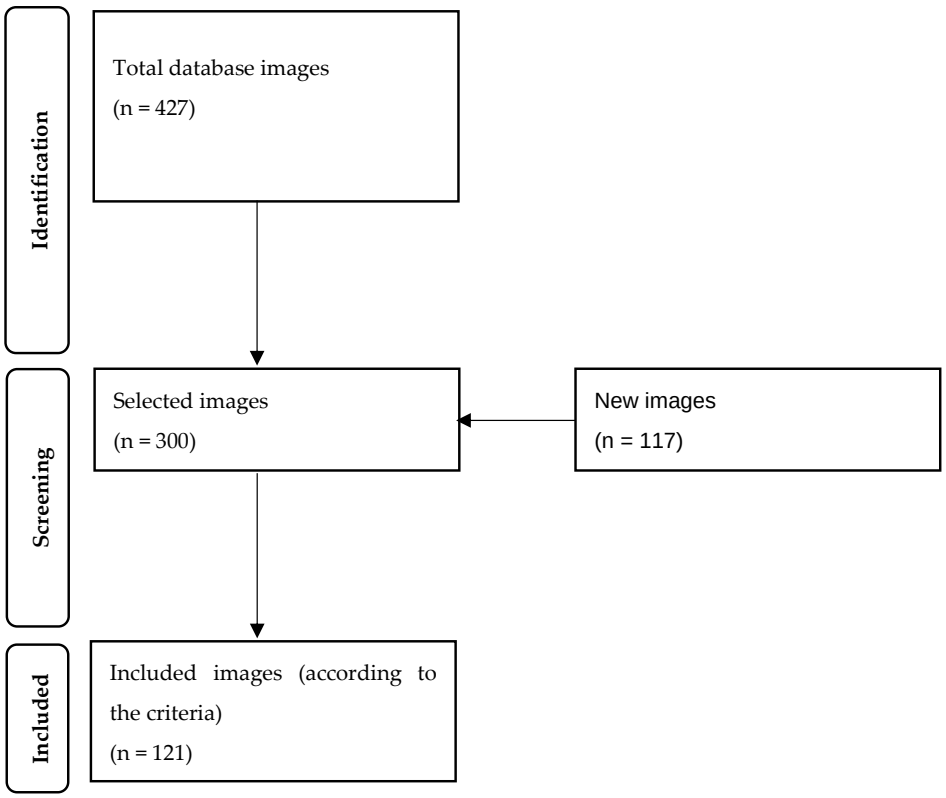

Figure 3. Data collection process according to inclusion and exclusion criteria. Note: own figure.

2.2.3. Power Analysis

The databases used had more than 11 million downloadable images. This means that if a confidence or security level (1-α) of 95% was applied, precision d = 5%, proportion p = 0.4 and expected proportion of losses R = 13.7%, the expected sample would be n = 427 images.

The minimum detectable difference between the scores was also estimated, given a sample of 300 subjects (images in this study) and power of 90%. To calculate the standardized difference between the scores, or the effect size, both the power is specified as the power (30, 40, 50, 60, 70, 80) and the sample size has the range n (100, 200, 300, 400), and both the G Power and the effect were analyzed (27). With this, the minimum detectable standardized difference given the requested power and the sample size was 0.16, which corresponded to an average score of approximately 536 and a difference between the scores of 17.

In short, a selection of 1000 images was obtained, for which it was proposed to measure the G Power and sample power [29]. To do this, the power obtained was analyzed for sample sizes from 100 to 427 when the scores increased to 100, 200, 300, 400 and 500, with a standard deviation of 117 images (Figure 4).

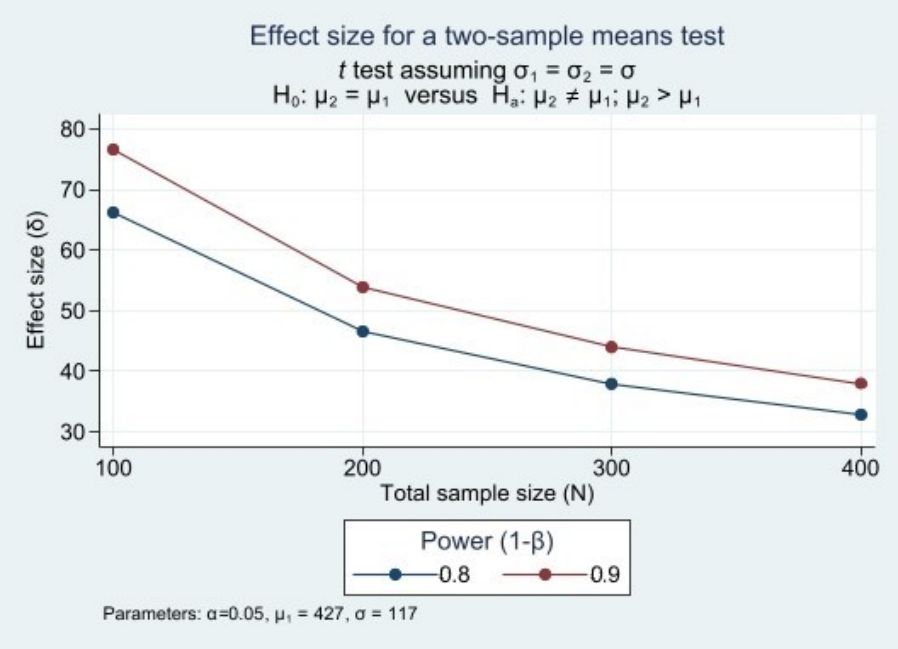

Figure 4. Estimated experimental group mean for a two-sample means test. Note: own figure. Created with Stata version 17.

2.2.4. Proposed Algorithms to Solve and Retrain Images

By employing a blend of advanced methodologies, this research also explored methods to enhance the images' comprehension and manipulation. This experiment enabled us to detect and address potential biases and stereotypes present within the visual data. This endeavor combined two technologies: deep learning, which aids computers in learning from patterns and examples, and quantum computing (QC), harnessing the principles of quantum mechanics.

In this pursuit, a sophisticated tool known as a convolutional neural network (CNN) served as a key component, analyzing the images to extract stereotyped features. Subsequently, these features underwent manipulation using quantum algorithms (QAs), leveraging quantum phenomena to streamline and accelerate the processing.

3. Results

The results for the analyzed images are divided into four different sections: the presence of aids and assistive devices; emotions and gender; the built and natural environment and sex; and digital images generated by AI.

3.1. Presence of Aids and Assistive Devices

Table 2 indicates the distribution of the types of aids and assistive devices linked to older people. Most of the devices were 'glasses' (74.4%) and 'canes' (14%). To a lesser extent, they included 'wheelchairs' (4.9%) or 'hearing aids' (0.8%) and the presence of more than one device simultaneously (5.8%).

Table 2. Distribution of types of aids and assistive devices in images of older people.

Aids and Assistive Devices	N	%
Walking stick	17	14.0
Wheelchair/walker	6	4.9
Glasses	90	74.4
Earphones	1	0.8
Cane and glasses	1	0.8
Cane and manual wheelchair	1	0.8
Medications/others	2	1.6
Crutches and glasses	2	1.7
Manual wheelchair and glasses	1	0.8
TOTAL	121	100

Representations of mixed groups predominated (38%), 31.4% were men, and the lowest representation was found for women (25.6%); sometimes, the gender/sex in the image was not recognized (4.9%). Furthermore, no images were found that represented gender diversity.

3.2. Emotions and Gender

The main emotional states represented were 'joy' (44.6%) and 'the emotion is not recognized' (44.6%). In a smaller proportion, 'sadness' (4.9%), 'surprise' (4.9%) and 'anger' (0.8%) were detected.

Differences were found in the gender/sex analysis in the represented emotions linked to aids and assistive devices. For example, as Figure 5 shows, although the categories of 'not recognized' (37%) and 'joy' (56.3%) predominated in the group of women and men, the emotion of 'sadness' had a greater presence in the group of women (12.9%). This result confirms, once again, some of the gender stereotypes observed in this virtual context.

Finally, the calculated Cohen's Kappa coefficient (−0.0608) suggested that the agreement between these emotions was very low. This could indicate that there was little consistency in how the emotions were labeled among the observers or that there was significant random disagreement in emotion classification. However, since the *p*-value was very high (1.0000), there was not enough evidence to conclude that the Kappa coefficient was significantly different from zero.

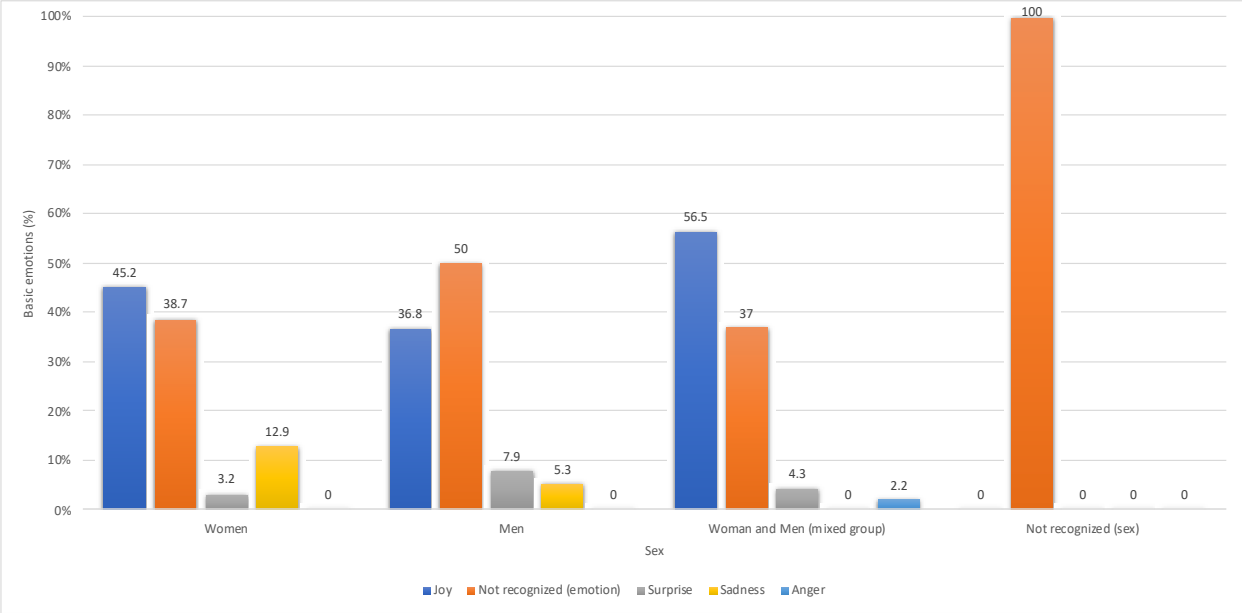

Figure 5. Analysis of basic emotions according to sex subgroups.

3.3. Analysis of the Built and Natural Environment

In the total images of older people linked to assistive technologies, 71.9% presented a built environment (87/121) and 10.7% a natural environment (13/121); in 17.4%, the environment was not recognized (21/121). Table 3 shows, in detail, the distribution of the types of built environment.

Table 3. Distribution of the types of built environment linked to aids and assistive devices in images of older people.

Built Environment	N	%
Commercial	13	4.9
Green space	20	23.0
Work/office	2	3
Not recognized	8	9.2
Technological space with screens	3	3.4
Others	5	5.7
Recreational (for example, park, square, playground, sports spaces)	9	10.3
Residential (refers to spaces in houses or urban buildings, both inside and outside)	22	25.3
Public services (e.g., police station, hospital)	4	4.6
Transport	1	1.1
TOTAL	87	100.0

When analyzing the natural environment (only identified in 13 of 121 images), it was observed that 66.7% were represented in aquatic spaces and 33.3% in green spaces, with the predominance of sunny meteorological conditions (9/13) and, to a lesser extent, cloudy conditions (3/13). Figure 6 shows a group of older people performing exercises in a closed environment, where one can see the outside space in the background. Despite exercising, all of the people appear sitting in chairs, which is also characteristic of the 'collective imagination' of passiveness regarding older people and old age within a built environment.

Figure 6. Image of a group of older people with wheelchairs, exercising in a closed environment with views of the outside. Source: https://www.pexels.com/es-es/foto/hombre-gente-mujer-nina-12085633/. Accessed on 12 August 2024.

For instance, as illustrated in Figure 7, although the categories of 'not recognized' and 'joy' were predominant in the groups of both women and men, the emotion of 'sadness' was more frequently observed in the group of women. This result reinforces the presence of gender stereotypes even within this virtual context. However, as the graph shows, most images (blue bars) depict built spaces, reaching over 70% for both men and women.

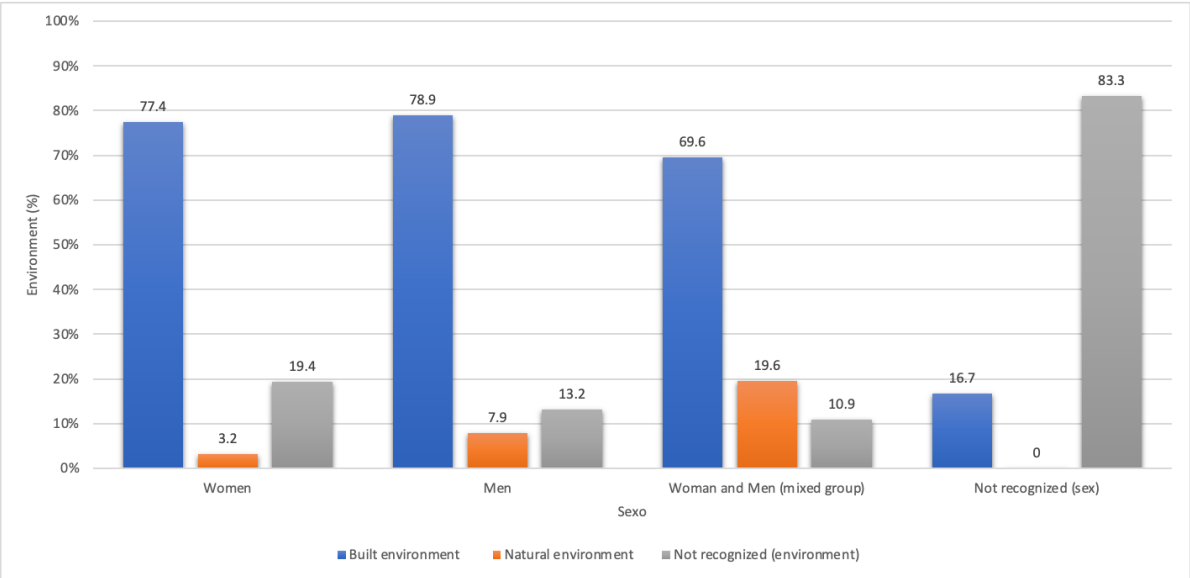

Figure 7. Analysis of the type of environment according to sex subgroups.

3.4. Digital Images Generated by AI

Below are some examples of digital images generated using the combination of all terms of interest in this work, namely 'aids and assistive devices', 'older people', 'emotions' (differentiating among joy, sadness, fear and anger, as shown in the images below), and

observations about this process. In Figure 8, there is a 'happy' older woman and three others where the type of emotion or a sense of 'calm' or 'tranquility' cannot be differentiated. The AI has not been able to determine whether the setting is mostly indoors or outdoors and whether the image depicts green land or another type of space/environment.

(**a**) (**b**) (**c**) (**d**)

Figure 8. Various images generated with AI. From left to right: two older women (**a**,**c**,**d**) and one older man (**b**) in different spaces. Source: images generated by https://facet.ai/artgpt. accessed on 12 August 2024.

3.5. Bridging Stereotype Identification and Manipulation in Images through Advanced Technologies

According to the results obtained in the previous sections, there are two prevalent features regarding stereotypes of older people. On one hand, it is common to find older people wearing glasses, and, on the other hand, hospital and nursing home environments

are depicted. The following outlines a framework spanning from the identification of stereotypical characteristics to their manipulation using techniques from deep learning and QC. Through this process, the aim is to mitigate biases and enhance the fairness and accuracy of image analyses, leveraging advancements in both artificial intelligence and quantum technologies. Based on the previous results, a working method is proposed to eliminate stereotypes in databases focusing on these two main characteristics. The following conditions enable the identification of common characteristics indicating stereotypes about older people:

- X is the set of features extracted from the images;
- Y is the set of labels indicating the presence of stereotypes about older people;
- Common characteristics xi are identified such that xi $\in$ X and yi = 1, where yi $\in$ Y.

The application of a CNN model enables the identification and suppression of such elements in the images:

- Let fCnn(I) be the function representing the convolutional neural network, where I is an image;
- The output of the CNN is a modified image Imod = fCnn(I).

The image features are exported: Xmod is the set of features extracted from the modified images. Image manipulation is applied by using QCA:

- fQC(Xmod) is the function representing the quantum algorithms applied to the features of the modified images;
- The output of the QA is a set of manipulated features Xmanip = fQC(Xmod).

4. Discussion

The analysis of digital images depicting older adults revealed several critical insights across various categories. Firstly, the representation of aids and assistive devices predominantly featured 'glasses' (74.4%), with less frequent portrayals of 'canes' (14%) and 'wheelchairs' (4.9%). 'Hearing aids' and the use of multiple devices simultaneously were rare, indicating the limited portrayal of the full spectrum of assistive technologies available. The gender representation in these images was skewed, with men depicted more frequently (31.4%) compared to women (25.6%) and a notable portion of images (38%) showing mixed gender groups.

This representation is significant given that assistive devices are crucial for the daily lives of many older adults. According to data, approximately 70% of older adults utilize at least one type of assistive device. The disparity between this statistic and their depiction in digital imagery underscores the substantial gap in how these technologies are represented. The underrepresentation of hearing aids and other assistive technologies not only neglects the variety of aids used by older adults but also reinforces a narrow view of ageing that fails to acknowledge the diversity of the assistive tools available.

The gender representation in these images was skewed, with men depicted more frequently (31.4%) compared to women (25.6%) and a notable portion of images (38%) showing mixed gender groups. This imbalance points to a lack of gender inclusivity in digital portrayals of older adults. Furthermore, the absence of diverse gender identities in these images highlights a broader issue of inclusivity.

The emotions portrayed in these images predominantly included 'joy' and 'unrecognized emotions', each at 44.6%, while other emotions, such as 'sadness', were less common. Gender differences were evident in the emotional representation, with women more frequently associated with 'sadness' compared to men, suggesting a potential gender bias in the depiction of emotions. The Cohen's Kappa coefficient for emotion agreement was very low (-0.0608), indicating significant variability in emotion classification among the observers and highlighting the inconsistency in the portrayal of emotions.

Regarding the environment depicted in the images, there was a strong bias towards built environments (71.9%), with natural environments represented in only 10.7% of the images. The built environments included residential and commercial spaces, while natural

settings were primarily aquatic or green spaces. This overrepresentation of built environments may contribute to a stereotypical view of ageing as confined to institutional or controlled settings.

Challenges with AI-generated images were also significant. AI systems often struggled to accurately depict emotions and environmental contexts, resulting in images with neutral or ambiguous expressions and idealized or futuristic settings that did not accurately reflect real-life scenarios. This discrepancy underscores the need for improved training data and more nuanced approaches to AI-generated imagery to better represent older adults.

These findings collectively highlight ongoing issues in the representation of older adults in digital imagery, including the prevalence of stereotypes, gender biases and limitations in emotional and environmental depiction. Addressing these issues through more inclusive and diverse visual content is essential in creating a more accurate and respectful portrayal of ageing.

4.1. Social Representation Theory and Its Impact on the Perception of Older Adults in Digital Images

Émile Durkheim, a pioneer in the study of collective representation, laid the groundwork for an understanding of how shared ideas and beliefs within a society influence social cohesion and the ways in which individuals perceive reality. Durkheim posited that these representations are social constructions that emerge from communal life and, in turn, shape the actions and thoughts of a society's members [30]. His approach profoundly influenced subsequent studies on the formation and function of social representations. A notable example is the work of Lévy-Bruhl, who, prior to Moscovici, explored the pre-logical mindsets of primitive societies, suggesting that forms of collective thought influence the perception of reality [31].

To better understand the implications of this study, the theory of social representation, developed by Serge Moscovici, has been adopted as the conceptual framework. This theory posits that social representations are systems of values, ideas and practices that are shared by the members of a community, which allow persons to interpret reality and communicate about it. These representations are generated and transmitted through media, discourses and cultural practices and have a significant impact on the formation of collective perceptions and attitudes [32–34].

In the context of this analysis, digital images representing older adults and assistive technologies not only reflect preexisting social perceptions but also play an active role in constructing and perpetuating these perceptions. For example, the recurrent depiction of older adults in stereotypical settings or with limited emotional expressions reinforces reductive and often negative views of ageing, which can influence how society as a whole perceives and values older adults and how they perceive their environments [35,36].

This theoretical framework allows for the understanding that the lack of diversity and the presence of stereotypes in digital images are not merely visual shortcomings but manifestations of a broader system of social representation that can perpetuate inequities and limit inclusion. Furthermore, these representations have the power to shape individual and collective expectations and behaviors, affecting how older adults see themselves and how they are viewed by others.

The socio-genetic perspective, which builds upon Moscovici's foundational concepts, extends this understanding by considering how biological factors might interplay with social processes in the formation of these representations. While Moscovici emphasized the social and cultural dimensions of representation, the socio-genetic approach adds a layer of complexity by exploring how inherent biological traits might influence or interact with the social construction of reality. This perspective enriches the original theory by integrating insights from genetics and biology into the analysis of how social representations are formed and sustained [37].

Thus, this study not only identifies technical shortcomings in the creation and selection of digital images but also highlights the need for a more nuanced approach to visual content

creation. By addressing both the social and biological dimensions of representation, and striving for more equitable and diverse depictions, it is possible to challenge and transform the prevailing social narratives. This comprehensive approach aims to foster a more inclusive and respectful portrayal of ageing and the technologies that support older adults, ultimately contributing to a more balanced and fair societal view.

Following this, Deborah Lupton has examined how social representations are being transformed in the digital age, particularly in the realm of health and the body. Lupton argues that information technologies and the proliferation of personal data are reshaping perceptions of identity and well-being, while also influencing social narratives about what is considered normal or desirable in terms of health. Her work highlights how digital representations not only reflect preexisting social realities but also actively shape them, promoting new discourses and practices in everyday life. These ideas are particularly relevant in understanding how digital images and other forms of visual content can affect collective perceptions and, ultimately, influence social attitudes and behaviors [38].

This study, therefore, not only exposes technical issues in the generation and selection of images but also underscores the need for a more critical and conscious approach to the creation and distribution of visual content in the digital era and AI-driven environments. AI-driven environments are contexts where artificial intelligence algorithms are used to generate, curate and analyze visual content. These systems can influence the types of images produced and how they are presented, often reflecting and amplifying existing biases. In this context, Ruha Benjamin explores how such technologies can perpetuate social and racial biases, highlighting the importance of addressing these issues to foster more equitable and inclusive digital spaces [39]. By addressing these biases and working towards more equitable and diverse representation in digital media, the dominant social narratives can be challenged and transformed, promoting a more inclusive and respectful view of ageing and the technologies that support this demographic group.

4.2. Challenges and Stereotypes in Digital Imagery

In the case of the presence of aids and assistive devices, the results were based on images that mostly represented glasses, canes and wheelchairs. In sum, gaps in the genders, emotions, and environments that were represented, as well as aids and assistive devices, were found. Furthermore, technological devices applied to health were not represented, which reflects a double stereotype. On the one hand, older people are represented with devices related to disabilities or mobility problems, and, on the other, they are not observed using innovative support technologies, as already mentioned in a previous study by some of the authors [40]. However, it seems that there is currently a trend towards the development of increasingly wearable devices and products for daily and everyday use, including more innovative ones, such as robots or digital solutions [4], but these were not yet visible in the images that were analyzed.

The absence of representation extends to innovative health technologies, revealing a double stereotype: older persons are depicted mainly with devices related to disabilities or mobility issues, while innovative solutions like wearable devices or robots remain largely absent. This disparity highlights persisting stereotypes within digital imagery and its portrayal of older adults and their assistive needs. The persistence of stereotypes in the representation of older adults in technology and assistance could be linked to the existence of a digital divide that, while narrowing, has not been fully accepted by society. This contradicts new understandings of adulthood and old age, which advocate for active participation and full integration into the digital age. The reluctance to recognize and adequately represent innovative technologies and assistance needs in old age reflects a disconnect between the changing realities and entrenched perceptions about ageing.

This study revealed several key findings. First, predominant emotions such as 'joy' were observed, along with cases where emotions were unrecognizable, with variations based on gender. This lack of emotional clarity varied by gender, suggesting that the representation of emotions may be influenced by gender biases or stereotypes. For example,

women may be depicted with less expressive emotional states compared to men, which could reinforce traditional gender norms. Second, most images depicted older adults in built environments, with few representations in natural settings. This reflects a lack of diversity in the contexts of representation that does not fully capture the reality of older adults' experiences. Third, AI-generated digital images presented challenges in accurately representing emotions and environmental contexts. AI-generated images often exhibited neutral or ambiguous expressions, and the environments were frequently idealized or futuristic, rather than reflecting real-life scenarios. This discrepancy between AI-generated images and real-world experiences highlights the need for more nuanced and diverse training data to improve the representation of older adults. In other words, for older adults to continue to be part of the silver economy and to adopt emerging technological devices, social images and their perceptions of themselves are vital. One way to address this challenge is to promote inclusive digital education for older adults and involve older adults in the process of creating and evaluating digital images. Their perspectives and experiences can provide valuable insights into how to enhance representation and inclusion in digital media. Additionally, it is important to encourage the more diverse and accurate representation of older adults in media and advertising, highlighting their active participation in society and their ability to adopt technology meaningfully. By showcasing positive and empowering examples of older adults using advanced technology effectively, it is possible to change public perceptions and foster a more positive attitude towards ageing and technology adoption in older people. To address this challenge, a generative AI algorithm with machine learning could be implemented to digitally analyze images of older individuals and assistive devices. This algorithm could be trained using a diverse and representative dataset including images of older individuals in various environments and situations, as well as a variety of assistive devices. Employing deep learning techniques, the algorithm could identify specific patterns and features in the images that are related to accurate representation of age, gender and the environment. Additionally, the algorithm could be designed to generate new and realistic images that reflect a range of contexts and emotions associated with ageing. This would help to improve the accuracy and diversity of representations of older individuals in digital media, thus reducing stereotypes and promoting a more accurate and positive image of ageing. The lack of diversity and the need for more positive and realistic representations of ageing across all realms, including media, advertising and popular culture, to foster a more inclusive and enriching view of the ageing process is still unresolved matter among digitalized societies [15,20,40]. This research also emphasizes stereotypes regarding aids and spaces, as the predominant types were glasses and hospitals/older residence spaces. Through the fusion of advanced methodologies, this research endeavors to enhance the comprehension and manipulation of images, aiming to detect and mitigate biases and stereotypes inherent in visual data. Integrating deep learning and quantum computing (QC), it leverages convolutional neural networks (CNNs) to analyze images for stereotypical features, followed by manipulation using quantum algorithms (QAs) to expedite their processing. This process includes identifying stereotypical features (X) and their labels (Y), modifying the images using a convolutional neural network (CNN) to produce altered images, and applying quantum algorithms to these modified features to generate manipulated features. The aim is to reduce the biases and enhance the fairness and accuracy in image analysis through these advanced technologies.

Among the other possibilities that quantum technology could offer is the optimization of AI algorithms used to analyze images of older adults and assistive devices. Quantum computing has the potential to significantly accelerate the calculations required to train and execute these algorithms, which could dramatically improve the efficiency and accuracy of image analysis. Moreover, QA is capable of handling large datasets more effectively, enabling a more comprehensive and detailed analysis of representations of older adults in digital media. One of the approaches that we could use to develop this algorithm is the adiabatic algorithm. The adiabatic algorithm relies on the controlled manipulation of a quantum physical system to find optimal solutions to optimization problems. It utilizes

the concept of adiabatic transitions to find the ground state of a quantum system, which corresponds to the solution of the optimization problem. By harnessing the quantum properties of the system, such as superposition and entanglement, the adiabatic algorithm can rapidly explore the solution space and efficiently find optimal solutions. On the other hand, a quantum annealer could be another option. A quantum annealer is a quantum device specifically designed to solve combinatorial optimization problems. It utilizes the phenomenon of quantum tunneling to find bit configurations that minimize an energy function associated with the optimization problem. Thus, quantum annealers are particularly effective in finding solutions close to global optima in complex optimization problems. Globally, quantum technology could help to enhance the quality and diversity of representations of older adults in digital media, thereby contributing to reducing stereotypes and promoting a more accurate and positive image of ageing.

Regarding emotions and gender, images were observed that showed mostly joy and a lack of recognition of emotion, especially in women. In general, it is observed that digital images linked to the use of aids and assistive devices among women are underrepresented. Evidence shows that while older people, especially older women, tend to be less represented in digital media [13], the differences become more acute when investigating how they are represented in a differential and stereotypical way in digital images [5].

The limitation of this study from a gender and feminist perspective has also been noted. In this context, a previous study showed that sexual and gender minorities face several challenges, especially in the use of digital platforms related to identity [41]; in another work, the author even concluded that digital images present a limited view of old age, excluding homosexual couples and non-binary people [5].

Although older people become 'invisible' in digital media [13], it is noted that men are more visible than women. The data also show marked differences in older people's use of media (traditional and digital), even among high-income countries (Canada, the Netherlands, Romania, Spain and Finland) [42]. In the same sense, the results of this work show the presence and co-existence of scenarios of gender/sex inequality and ageism in the representation of older people in this collective digital imagination.

Regarding the representation of the natural environment, in digital images, an excess of this appears, particularly emphasizing sunny weather, which is even visible in closed spaces. This emphasizes that, where older people appear, the idealization of the natural space is visible, which, according to García Monteagudo, could make it difficult '*to understand their social environment*' [43] and hides the reality or challenges that are emphasized in the present study. Older people using aids and assistive devices were predominantly represented in built environments (for example, nursing homes) and scarcely in natural environments, with a balance being necessary in the representation of these spaces. As evidenced by a previous study from the perspective of older people, the physical, social and nature-based qualities of everyday environments are important with regard to good ageing [44]. This also highlights the role of connecting with nature, both inside and outside built environments, in promoting healthy ageing [45]. This result is key, particularly in regard to the representation of women in the built environment (such as nursing home environments), as has been shown by previous work on digital images, where older women are largely linked within the home with care roles [5].

From the above, the representation in digital media (images) of the older adult population from an inclusive and intersectional perspective (gender, age, space) is crucial. For example, as suggested in a study conducted during the COVID-19 pandemic, problematic representations of older people in the media could evoke or amplify age discrimination [46]. In short, the stereotypes observed in this work are accentuated when an intersectional approach is considering involving age and sex, among other aspects, also highlighting the environment [47–50].

Regarding the images analyzed by AI, expressions are observed that evoke predominantly neutral emotions, as well as futuristic environments. This leads to the suggestion that AI, as noted for built environments, shows an idealized and stereotyped environment,

which can also make it difficult for older people to understand the importance of innovative technology. In the studied digital images, the presence of faces where the expression could not be detected was frequent, which suggests that more research should be conducted into the identification of emotions to allow the assessment of the degree of acceptance of the technology by the users themselves regarding the adoption of new technologies. With this, it is possible, in turn, to apply agent-based models (computational simulations) to test stochastic process algorithms so as to address the 'technological divide' that is still present in older people [51].

In the images not generated by AI, limited emotions beyond joy stand out, as the authors have already indicated in a previous study [5], which suggests that the wide range of emotions that could be expressed is not being recognized. Furthermore, as stated in a previous review [52], when older people are represented in the media (both digital and non-digital), they are largely represented as a homogeneous group and without individual differentiation, even from an exaggeratedly positive perspective. However, it can be highlighted that, in a significant proportion of images, the emotion could not be recognized (due to neutral or ambiguous expressions, an absent gaze, a lack of reaction or a state of peace/tranquility, depending on how it is interpreted, as we have noted previously).

4.3. Limitations and Strengths

In this work, limitations related to the virtual ethnography method itself can be identified, such as access to resources in specific databases and the 'ephemeral' nature of the data. However, all of the images were downloaded and the functioning of the links was reviewed on more than one occasion and at different times, finding, at the time of the last consultation, a small proportion of images that were no longer available online (only one of 114 images and their respective links).

There could have been information bias or under-recording (for example, we limited ourselves to a certain number of databases and assigned the categories of interest within a limited period), although, as indicated in the Materials and Methods section, different measures were taken to mitigate this.

Moreover, the initial analysis of Cohen's kappa showed some discrepancies in the emotion labeling, which we view as an opportunity for improvement rather than a limitation. It was expected due to the limited number of individuals involved in the labeling process. These findings emphasize the importance of refining and further validating the methods to ensure reliable results in the future. By implementing targeted enhancements, such as standardizing the labeling criteria, expanding the pool of labelers and conducting qualitative analyses, the future analysis of the database of images can achieve improved accuracy and consistency in emotion labeling. This iterative approach not only enhances the study's validity but also deepens our understanding of emotional nuances. Thus, while the initial results may indicate areas for improvement, they signify the beginning of an enriching journey towards more nuanced and insightful findings in emotional image codification.

Moreover, the images analyzed in this study included a significant proportion of promotional material. This aspect should be considered when interpreting our findings. Promotional images are often designed to capture attention and promote specific products or services, which can influence how older adults are represented, often focusing on aspects that resonate with the target audience's expectations and marketing ideals. This promotional orientation can contribute to the perpetuation of stereotypes by depicting older adults in ways that align with prevailing social perceptions and expectations. However, the fact that these images come from promotional contexts does not invalidate their relevance in the discussion about public perception and stereotypes associated with ageing. On the contrary, it underscores the need for greater critical reflection on how visual representations influence social perceptions and the acceptance of emerging technologies among older adults. This study aimed not only to describe the content of the images but also to understand how these representations may reflect and, in turn, reinforce certain social perceptions and expectations. Future work would benefit from combining image analysis

with additional research on how social perceptions and market expectations influence the representation of older adults. This would provide a more comprehensive and critical view of the impact of promotional images on the construction of identity and the social integration of older adults.

In addition, there were limitations in the use of AI, as stated in the Materials and Methods, but it was possible to verify, in the generated images, the representation of expressions related to emotions. In older people, they are 'neutral', or, if possible, they convey absence (gaze lost or fixed on the horizon) or inexpression (or 'calm' or 'tranquility', depending on how it is interpreted). Regarding health and environmental support technologies, although representations that resemble reality are displayed, they usually present older people within 'futuristic' and 'unrealistic' contexts.

In relation to the initial and exploratory use of AI in this area, and due to the limitations found and already stated (in comparison with images retrieved from digital repositories), it is possible to highlight the quality of the images provided (the distortion of some images when several terms are introduced at the same time) and also the subscription. These aspects remain a future challenge, and a more in-depth analysis is required in light of the ethical aspects related to algorithmic discrimination and data bias [53]. Moreover, stock images or AI are pervasive on the web and apps are increasing in number. There is a blind spot in the ethics of stock images regarding the use of such images without training [54], which is a complex and relevant aspect to be analyzed when implementing AI. However, these aspects are beyond the scope of this work and may be explored in future studies that explore image databases and apply the ethics approach.

The main limitation of this study in this regard is the consideration of an app to generate images, as it used mainly images from the Low-Rank Adaptation of Large Language Models AI (LoRA AI) [55]. The LoRA AI utilizes large-scale language models like the Low-Rank Adaptation (LoRA) model, which has been widely employed to generate digital images with a wide range of features. The LoRA AI has the potential to significantly contribute to diversity and inclusion in visual representation, as it can generate images depicting people of different ages, abilities, cultural backgrounds and genders. However, it is important to recognize that the quality and representativeness of AI-generated images may be influenced by biases present in the datasets used to train these models. Therefore, addressing these ethical concerns and ensuring that AI-generated images accurately and equitably reflect societal diversity is crucial.

The quality and representativeness of AI-generated images, including those produced by models like the LoRA AI, still require further evaluation. Issues such as image distortion and a lack of diversity, as highlighted in this study, emphasize the need for additional research to assess the reliability and accuracy of these generated images. Variability in image quality and potential biases in training data can affect how emotional images are interpreted, which could have significant implications for inclusion and accuracy in emotion coding. In addition to concerns specific to the LoRA AI, it is crucial to consider broader challenges associated with AI-generated imagery. For instance, the training datasets used to develop these models often contain inherent biases that may perpetuate stereotypes or underrepresent certain groups. This is particularly important when evaluating emotional and social representations in images. Furthermore, the algorithms themselves may struggle in accurately depicting nuanced emotional expressions, particularly in diverse populations or complex contexts. Addressing these issues requires not only optimizing the AI models but also conducting comprehensive studies that examine the broader implications of these technologies. This includes ensuring that AI-generated images accurately reflect societal diversity, as well as exploring how different AI models handle various emotional and contextual nuances. By tackling these challenges, future research can contribute to more inclusive and precise representations in AI-generated imagery.

4.4. Future Directions and Ethical Considerations

Future studies need to focus more on the LoRA AI instead of the training images. Although this study did not analyze the LoRA AI, the academic literature on this subject, to our knowledge, is lacking. Therefore, it is worth highlighting that this is an important approach that should be applied in the representation of images in future works, in addition to the virtual ethnographic evaluative method on which this study focused.

It is worth highlighting some observations related to AI when applying the terms of interest (older people, women/men and aids/assistive devices). In most cases, the use of the variable 'older people' causes AI to generate images of older women, while older men are represented only when they are directly specific. One reason for this finding could be that older women are directly linked to old age and to assistive technologies or that AI takes into account life expectancy according to sex. However, a more comprehensive analysis of these ideas, as well as new tests and the standardization of procedures, is needed to establish a conclusion in this regard. Another issue is the limited representation of aids/assistive devices and older people, suggesting that they are not yet fully included in AI. Some AI difficulties have also been observed in understanding other concepts, such as 'ageism' and the spatial/contextual aspects of this. Finally, confirming the need for specific and more standardized searches in the future in the field of images obtained from AI, the ethnic, racial and sexual diversity was poor (almost all images were of white individuals with a normative appearance). This last aspect is partly consistent with some findings from the analysis of digital images in repositories.

For this evaluative study, and as a general conceptual framework, our work was based on previous ones, such as [56–59].

There are studies regarding image evaluation guidelines from a social and/or gender perspective [24,60] but few on the evaluation of digital images according to age, space/land and gender. There are already hundreds of works on evaluation and gender [61] but very few on evaluation, images and gender (and less with a feminist approach) or on older people and the environment/land.

Moreover, advancements in AI have both positive and negative implications for these representations. AI technologies are increasingly used to generate and analyze digital images, including those of older adults. While AI has the potential to create more inclusive and diverse representations by recognizing and mitigating biases in image datasets, it can also perpetuate existing stereotypes if not carefully managed. For instance, AI algorithms trained on biased data can inadvertently reinforce negative stereotypes about ageing and gender, leading to the greater presence of stereotypical images of older women. Therefore, AI-generated images are not aware of and do not actively counteract these biases. This involves curating diverse and representative datasets, implementing fairness and bias detection mechanisms and promoting ethical guidelines in AI development. In this way, AI can help to foster more accurate and positive representations of older adults, particularly women, contributing to a more inclusive and equitable society. In the future, generative AI should serve as an ally for the evaluation of images and for social evaluation and research as a whole, as well as, more specifically, in the areas addressed here.

On the other hand, AI images are currently trained with datasets such as CIFAR-10 [1], MNIST [2] and COCO [3], which are not specifically designed in consideration of social concepts such as inclusion and contain implicit biases and stereotypes [62,63]. In this context, apps play an interesting role in research and could be used to pursue objectives related to inclusion. For example, the project FAT/Lm explores databases with training images applying ethical and inclusion concepts. In the case of this study, ArtGPT provided images for a wide range of individuals, including those with different abilities and cultural backgrounds, ethnicities and ages, by engaging artistic expression. ArtGPT could contribute to inclusion by giving a voice to those who may have traditionally been marginalized in conventional artistic circles.

This point is very important as it is an emerging finding and it is necessary to foster positive attitudes towards older persons and their use of technologies.

However, it is also important to consider how the underlying artificial intelligence model behind ArtGPT is trained and utilized. If the data used to train the model are biased or represent only certain artistic styles, genders or cultures, the responses generated by the application could reflect and perpetuate these biases, which could have a negative impact on inclusion and diversity in the art field. Thus, a social perspective is needed to support greater representation in apps such as ArtGPT, enabling them to generate representations inspired by diverse groups of older people, using technological devices, in realistic environments and with differentiation by gender, contributing to reducing ageism and fosting more inclusive and intersectional views in general. Regarding this study and its method, it cannot be inferred that the results obtained from the digital images reflect real representations of the elderly. Therefore, future studies that also include the perspectives of older people themselves are needed.

Additionally, the representation of older adults in digital images reveals a series of persistent stereotypes and a lack of diversity in the depiction of technologies and environments. These observations have significant implications for policy formulation and spatial planning. The prevalence of stereotypical representations, such as the predominant use of basic assistive devices and the exclusion of advanced technologies, underscores the need for policies that promote more inclusive and accurate representation. Public policies should encourage the integration of diverse representations in digital media and educational campaigns to adequately reflect the realities of older adults. Additionally, urban planning should consider the inclusion of both natural and built spaces that meet the needs of older adults, promoting active and healthy ageing. Collaboration between policymakers, technology developers and older adult communities is essential to ensure that environments and technologies are accessible and representative.

In this context, emotional intelligence becomes relevant. The ways in which emotions are represented in digital images and, especially, with artificial emotional intelligence technology can exert a social impact [39] on how older adults and society in general experience and manage their own and others' emotions. Limited or stereotypical emotional representations can contribute to a lack of empathy towards older adults, perpetuating a one-dimensional and limited understanding of their experiences. On the other hand, a more diverse and emotionally rich representation could foster greater empathy and understanding, which is crucial for more equitable representation and inclusion.

5. Conclusions

This study revealed that digital imagery of older adults frequently perpetuates stereotypes and age discrimination. Notably, gender disparities were evident, with older women being less represented and portrayed in more traditional and limiting roles compared to their male counterparts. This finding is particularly relevant given the demographic shift towards an increasingly older population, where gender inclusivity in representation is a relevant factor. The disproportionate representation of older women and the reinforcement of reductive stereotypes in digital media contribute to the persistence of ageist attitudes and fail to capture the diverse experiences of ageing. These results highlight the urgent need for more nuanced and equitable portrayals that accurately reflect the complexity and vitality of the ageing population.

The evaluation of the final images confirmed the lower representation of women and limited emotional expressions in images of older people, highlighting the persistent stereotypes and biases in digital imagery. Despite technology's omnipresence, images often overlook innovative support technologies for older people. Moreover, AI struggles to accurately depict emotions and environments in digital images, indicating the need for thorough pretraining analysis and ethical considerations.

The analysis revealed predominant emotions such as 'joy' and the greater representation of older people in built environments compared to natural settings. Gaps were identified in gender representation, emotional expression, environmental depiction and the representation of assistive devices. Additionally, innovative health technologies were

notably absent, perpetuating stereotypes of older adults with disability-related devices. The persistence of such stereotypes may stem from the digital divide and societal reluctance to fully embrace ageing and technological advancement. There is still a challenge regarding the promotion of inclusive digital education and the accurate representation of older adults in media and advertising. By showcasing positive examples of older adults using technology effectively, public perception can be shifted towards a more positive attitude towards ageing.

Generative AI algorithms and quantum technology offer solutions to enhance the accuracy and diversity of representations of older adults in digital media. Furthermore, combining convolutional neural networks with quantum computing algorithms could offer a powerful approach to reducing biases and improving both fairness and precision in image analysis. These advancements have the potential to significantly enhance the efficiency and accuracy of image analysis, but ethical considerations are paramount. Future research should prioritize inclusivity and explore older adults' perspectives to ensure a comprehensive understanding and representation in digital imagery.

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Notes

[1] https://www.cs.toronto.edu/~kriz/cifar.html. Accessed on 12 August 2024.

[2] https://www.tensorflow.org/datasets/catalog/mnist. Accessed on 12 August 2024.

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