Andres Burbano andres@shopline.fr Paris-Saclay University / Shopline Electronic

Assistive computer vision: ten years of technological transfer and research with future prospects

Ten years ago, the assistive technologies problems were the lack of programmatic foci and the short and undeveloped fields of applications, concentrated in a few beneficiaries [1]. A decade later, these problems were overcome as several fields and educational programs flourished. Thanks to the evolution of new technologies, fields like robotics [2] and computer vision [3] were explored. At the same time, the assistive technologies population scope grew from students with language and speech disabilities to a wider range of disabilities[3]–[5], elderly [6] and people in rehabilitation[7], [8]. A great number of these works were developed using the Microsoft Kinect, an RGB-D active camera based on structured light pattern [9]. It was developed by PrimeSense, commercialized by Microsoft and Asus and finally bought by Apple, who pulled it out of the market. This camera had an incredible impact in the academic and industrial worlds, even after its unavailability, not only in assistive technologies but in several fields like telemedicine [10], [11] or smart environments [12]. However, *why does a technology with that incredible influence have such little outcome in terms of social impact in the real-world?* In order to answer this question, I will analyze the Microsoft Kinect life cycle in the computer vision field, the real impact of the technology in the society and the path of a solution from the conception to the market. The purpose of this work is to identify the current problematic of the assistive technologies after ten years of technological transfer and research. As a result, we identify the social exclusion generated by technology, the low cohesion between the different actors of the society that weakens the impact of the academic research, the lack of use of conscientious studies as the basis for technology innovation and research along with the lack of institutional and governmental policies that ensure the continuity and completeness of projects.

In 2010, the Microsoft Kinect appearance propelled several computer vision academic [13], [14] works, due to the inexpensive [15] or low cost [8] and the acceptable results [16]. The real developer over this technology was PrimeSense [17], an Israeli company. During six years, this technology revolutionized the academic and the industrial world, until its disappearance. At the same time, global manufacturers tried to develop their own solution, hoping to have the same impact and level of democratization. Intel, Google, Parrot and Etron are the companies that developed similar solutions for 3D sensing. In my current investigation, I compared most of these solutions with the PrimeSense depth camera and none of them have the same performances to replace it. Now, the first question that arises is to know what will be the impact in the academy. Last month, I had the opportunity to ask a French academic community with a relevant expertise in 3D depth sensors - what will be the future of these works all based on the Kinect? - From my understanding, they judge that most of this knowledge can be ported to current depth sensors or sooner or later a new product will appear. Even if they were not very sure, it is a fact that the time in research is not imperative but what about the industry? The business transaction of the purchase by Apple occurred in 2015, camera stocks finished early 2016. The different companies that relied on this messianic technology to innovate are known redesigning their products and finding a technology replacement struggling to survive. Counting people, shoppers' perception and 3D modeling small and medium companies were drastically affected[1].

The analysis of the Kinect life cycle pointed out how the private interest and the monopoly in the point technologies can drastically affect the scientific research, probably impeding several remarkable solutions to finally help society, but also highlights the lack of interaction between the different stakeholders to prevent and minimize this kind of risks. Additionally, we identified the lack of

1 Currently I am doing a CIFRE thesis that is a French Scholarship to promote the research and development in the industry. I am currently working for a people counting company that created one of it products based in the Asus Xtion Pro.

institutional and governmental policies at the moment to assess the projects' feasibility and the budget assignation.

Our second element of analysis is the real impact of the new technology into the society; we took into account two ways in which the new technologies become available to the population. First, the commercialization of the product by a company, that requires a complete market research and a business plan to ensure that business model. Second, the government services implementation in compliance with a public policy providing services [18]. We identified diverse issues related to assistive technology and in technology in general. One of the most interesting issues is the social exclusion. Yates [18] analyzed how the UK government welfare policies in 2015, supposed to assist the vulnerable population in order to improve their access to the welfare services, ended up into enlarging the social exclusion gap. He also pointed out "the intimate relationship that exists between digital exclusion and social exclusion" reflected in government lack of understanding about the vulnerable population and their needs. The social exclusion is studied from the ethical point of view [19]. Wikins discuss the risk of social exclusion of vulnerable populations, by the use of biometrics for people identification as generalized policy. Even if the point is to restrict the access to the persons with the wrong identifiers, the unfair restriction to disable people to social goods as healthcare, social security, employment and housing generates an ethical concern. Another general issue is the natural rejection of the people to new technologies for cultural reason, especially the elders [20]. The following is a nonexhaustive list of the excluded social groups compiled from the described articles above and to explicitly show the relevance to these populations to assistive technologies field.

- The people with physical and/or learning disabilities
- The people with mental illness
- The people of certain races or ethnic minorities
- The people likely to be unemployed.
- The elderly (over 55)
- The homeless

.Those articles also evidence the innovation blindness [21] from the academy and the governments. While the academy is developing new innovative solutions and the government are using new technology to economize welfare services, the population real problems are not been solved and are demanding more accurate and well-based solutions. The articles also suggest that the technology itself is not the problem, but its use.

As a result of this analysis, we identify the elderly, the lower rated social classes and the disabled or with long term health issues as the main excluded population by the new technologies. We identify the academy, the industry and the government as main actors in the development of new technologies with a lack of an organized interaction between them. Furthermore, we identify that not only the more vulnerable population has the less access to technology, but also the rejection to change are the main causes of the low impact of the new technologies in the society.

In conclusion, the computer vision research and development has been progressively increasing at the same time as the social exclusion gap instead than the former helped to decreased the latter, due to the lack of strengthening relationships between the actors to identify the real needs of the vulnerable population. In order to create socially equitable solutions with real impact into the society, we have to overcome the innovation blindness [21] building an integral overview at the moment to evaluate the future projects by assessing the scientific relevance but also the project implementation feasibility and large-scale deployment. The academy should work closely with the private sector and the government, presenting the scientific community as the first allied to solve and prevent society problems. We have the moral duty to start developing solutions available even to the most vulnerable population and stop building a technological palace where only a few have access.

In order to have a relevant, equitable and real impact on the society, the future perspective of the assistive computer vision imperatively should meet the following issues: a deep understanding of the society needs and problems by partnering with different academic fields like anthropology or sociology that have a closer overview of the society. Strengthen relationships with the industry and manufacturers to ensure the supply of point technologies at low cost, whilst speeding up the time to bring these solutions to the market. Finally, obtain the governmental support to create a policy framework that promotes the assistive projects by funding their research and ensuring access to the vulnerable population to these technologies.

References

[1] C. M. Okolo and E. C. Bouck, "Research about assistive technology: 2000-2006. What have we learned?," *J. Spec. Educ. Technol.*, vol. 22, no. 3, p. 19, 2007.

[2] F. Werner, D. Krainer, J. Oberzaucher, and K. Werner, "Evaluation of the Acceptance of a Social Assistive Robot for Physical Training Support Together with Older Users and Domain Experts," *Assist. Technol. Res. Pract. AAATE 2013*, vol. 33, p. 137, 2013.

[3] X. Chai, G. Li, X. Chen, M. Zhou, G. Wu, and H. Li, "Visualcomm: A tool to support communication between deaf and hearing persons with the kinect," in *Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility*, 2013, p. 76.

[4] Y.-J. Chang, S.-F. Chen, and J.-D. Huang, "A Kinect-based system for physical rehabilitation: A pilot study for young adults with motor disabilities," *Res. Dev. Disabil.*, vol. 32, no. 6, pp. 2566–2570, 2011.

[5] R. Chavarriaga, M. N. Hurtado, M. Bolanos, J. A. Loaiza, J. M. Mayor, M. Valencia, and J. Aguilar-Zambrano, "Multidisciplinary design of suitable assistive technologies for motor disabilities in Colombia," in *Global Humanitarian Technology Conference (GHTC), 2014 IEEE*, 2014, pp. 386–391.

[6] C. Rougier, E. Auvinet, J. Rousseau, M. Mignotte, and J. Meunier, "Fall detection from depth map video sequences," in *Toward Useful Services for Elderly and People with Disabilities*, Springer, 2011, pp. 121–128.

[7] L. Neri, G. Adorante, G. Brighetti, and E. Franciosi, "Postural rehabilitation through Kinect-based biofeedback," in *Virtual Rehabilitation (ICVR), 2013 International Conference on*, 2013, pp. 218–219.

[8] B. Lange, C.-Y. Chang, E. Suma, B. Newman, A. S. Rizzo, and M. Bolas, "Development and evaluation of low cost game-based balance rehabilitation tool using the Microsoft Kinect sensor," in *Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE*, 2011, pp. 1831–1834.

[9] D. Pagliari and L. Pinto, "Calibration of Kinect for Xbox One and Comparison between the Two Generations of Microsoft Sensors," *Sensors*, vol. 15, no. 11, pp. 27569–27589, 2015.

[10] A. Kadkhodamohammadi, A. Gangi, M. de Mathelin, and N. Padoy, "3D Pictorial Structures on RGB-D Data for Articulated Human Detection in Operating Rooms," *ArXiv Prepr. ArXiv160203468*, 2016.

[11] N. L. Rodas, F. Barrera, and N. Padoy, "Marker-Less AR in the Hybrid Room Using Equipment Detection for Camera Relocalization," in *Medical Image Computing and Computer-Assisted Intervention–MICCAI 2015*, Springer, 2015, pp. 463–470.

[12] A. Burbano, S. Bouaziz, and M. Vasiliu, "3D-sensing Distributed Embedded System for People Tracking and Counting," in *2015 International Conference on Computational Science and Computational Intelligence (CSCI)*, 2015, pp. 470–475.

[13] J. Han, L. Shao, D. Xu, and J. Shotton, "Enhanced computer vision with microsoft kinect sensor: A review," *Cybern. IEEE Trans. On*, vol. 43, no. 5, pp. 1318–1334, 2013.

[14] K. Berger, S. Meister, R. Nair, and D. Kondermann, “A state of the art report on kinect sensor setups in computer vision,” in *Time-of-Flight and Depth Imaging. Sensors, Algorithms, and Applications*, Springer, 2013, pp. 257–272.
[15] E. Stone and M. Skubic, “Evaluation of an inexpensive depth camera for in-home gait assessment,” *J. Ambient Intell. Smart Environ.*, vol. 3, no. 4, pp. 349–361, 2011.
[16] K. D. Mankoff and T. A. Russo, “The Kinect: A low-cost, high-resolution, short-range 3D camera,” *Earth Surf. Process. Landf.*, vol. 38, no. 9, pp. 926–936, 2013.
[17] B. Freedman, A. Shpunt, M. Machline, and Y. Arieli, “Depth mapping using projected patterns,” US20100118123 A1, 13-May-2010.
[18] S. J. Yates, J. Kirby, and E. Lockley, “‘Digital-by-default’: reinforcing exclusion through technology,” *Def. Welf. 2*, p. 158, 2015.
[19] J. Wickins, “The ethics of biometrics: the risk of social exclusion from the widespread use of electronic identification,” *Sci. Eng. Ethics*, vol. 13, no. 1, pp. 45–54, 2007.
[20] P. M. Leonardi, “Why do people reject new technologies and stymie organizational changes of which they are in favor? Exploring misalignments between social interactions and materiality,” *Hum. Commun. Res.*, vol. 35, no. 3, pp. 407–441, 2009.
[21] P. M. Leonardi, “Innovation blindness: Culture, frames, and cross-boundary problem construction in the development of new technology concepts,” *Organ. Sci.*, vol. 22, no. 2, pp. 347–369, 2011.