Abstract

Despite the importance of agricultural grains appearance for their choice by the consumers as well as for determining their selling price, the visual inspection of the quality of these products is usually conducted in a manual way and, therefore, susceptible to high operational costs, human errors and inaccurate results. Recently, a computer vision system for quality inspection of beans composed by a set of hardware and software, named the SIVQUAF, was proposed in the literature. However, the software of the SIVQUAF was designed for a personal computer, which makes its operation more complex, decreases its performance and raises the cost of the equipment. Thus, in this work we explored the customization and optimization of SIVQUAF aiming its running on a Raspberry Pi 3, keeping similar performance, generating the SIVQUAF(Compact. Besides redesigning and parallelizing algorithms, we proposed improvements in the classification and defect detection steps, and a new touch-sensitive interface. The experiments conducted with SIVQUAF(Compact embedded in a Raspberry Pi 3 demonstrated that in addition to reproducing high hit rates in the tasks of segmentation (97.50%), classification (97.06%) and detection of defects (74.78%), there was a significant
gain in terms of cost, operation and compaction of the equipment, increasing its operational, technical and economic viability.

References

1. J. Coêlho, Grain production - beans, corn and soybeans, Cad. Setorial ETENE, Fortaleza. (2017) 1–14.
2. A.K. Aggarwal, R. Mohan, Aspect Ratio Analysis Using Image Processing for Rice Grain Quality, Int. J. Food Eng. 6 (2010) 1–14. https://doi.org/10.2202/1556-3758.1788.
3. MAPA, Ministério Da Agricultura Pecuária e Abastecimento - Projections of agribusiness Brazil 2014/2015 to 2024/2025 Long term projections, Ministério da Agricultura, Pecuária e Abastecimento, Brasilia, Brasil, 2015. http://www.sapc.embrapa.br/arquivos/consorcio/informe_estatistico/Projecoes_Agronegocio_AFE_Mapas_2015_2025.pdf (accessed April 1, 2018).
4. G. Stegmayer, D.H. Milone, S. Garran, L. Burdyn, Automatic recognition of quarantine citrus diseases, Expert Syst. Appl. 40 (2013) 3512–3517. https://doi.org/10.1016/j.eswa.2012.12.059.
5. N.K. Patil, R.M. Yadahalli, J. Pujari, Comparison between HSV and YCbCr Color Model Color-Texture based Classification of the Food Grains, Int. J. Comput. Appl. 34 (2011) 51–57.
6. J.D.D. Cabral, S.A. de Araújo, An intelligent vision system for detecting defects in glass products for packaging and domestic use, Int. J. Adv. Manuf. Technol. 77 (2015) 485–494.
7. J. Posada, C. Toro, I. Barandiarian, D. Oyarzun, D. Stricker, R. de Amicis, E.B. Pinto, P. Eisert, J. Döllner, I. Vallarino, Visual computing as a key enabling technology for industrie 4.0 and industrial internet, IEEE Comput. Graph. Appl. 35 (2015) 26–40.
8. A. OuYang, R. Gao, Y. Liu, X. Dong, An Automatic Method for Identifying Different Variety of Rice Seeds Using Machine Vision Technology, in: 2010 Sixth Int. Conf. Nat. Comput., 2010: pp. 84–88.
9. H. Zareiforoush, S. Minaei, M.R. Alizadeh, A. Banakar, B.H. Samani, Design, development and performance evaluation of an automatic control system for rice whitening machine based on computer vision and fuzzy logic, Comput. Electron. Agric. 124 (2016) 14–22. https://doi.org/10.1016/j.compag.2016.01.024.
10. P.A. Belan, Sistema de visão computacional para inspeção da qualidade de grãos de feijão, Universidade Nove de Julho, 2019.
11. Q. Yao, Y. Zhou, J. Wang, An automatic segmentation algorithm for touching rice grains images, in: Audio Lang. Image Process. (ICALIP), 2010 Int. Conf., Shanghai, China, 2010: pp. 802–805. https://doi.org/10.1109/ICALIP.2010.5685114.
12. G. Venora, O. Grillo, C. Ravalli, R. Cremonini, Identification of Italian landraces of bean (Phaseolus vulgaris L.) using an image analysis system, Sci. Hortic. (Amsterdam). 121 (2009) 410–418. https://doi.org/10.1016/j.scienta.2009.03.014.
13. B.S. Anami, D.G. Savakar, Influence of light, distance and size on recognition and classification of food grains’ images, Int. J. Food Eng. 6 (2010). https://doi.org/10.2202/1556-3758.1698.
14. B. Laurent, B. Ousman, T. Dzudie, M.F.M. Carl, T. Emmanuel, Digital camera images processing of hard-to-cook beans, J. Eng. Technol. Res. 2 (2010) 177–188.
15. J. Liu, W.W. Yang, Y. Wang, T.M. Rababah, L.T. Walker, Optimizing Machine Vision Based Applications in Agricultural Products by Artificial Neural Network, Int. J. Food Eng. 7
An Embedded Computer Vision System for Beans Quality Inspection

(2011) 1–25. https://doi.org/10.2202/1556-3758.1745.

16. J.H. Pessota, Sistema especialista aplicado à inspeção da qualidade visual de grãos de feijão., Universidade Nove de Julho, 2013. http://bibliotecatede.uninove.br/handle/tede/206 (accessed August 26, 2020).

17. M.R. Siddagangappa, A.H. Kulkarni, Classification and Quality Analysis of Food Grains, J. Comput. Eng. 16 (2014) 01–10.

18. R. Kambo, A. Yerpude, Classification of Basmati Rice Grain Variety using Image Processing and Principal Component Analysis, Int. J. Comput. Trends Technol. 11 (2014) 80–85. https://doi.org/10.14445/22312803/ijctt-v11p117.

19. P. Dubosclard, S. Larnier, H. Konik, A. Herbulot, M. Devy, Automatic method for visual grading of seed food products, Lect. Notes Comput. Sci. (ICIAR 2014). 8814 (2014) 485–495. https://doi.org/10.1007/978-3-319-11758-4_53.

20. P. Dubosclard, S. Larnier, H. Konik, A. Herbulot, M. Devy, Deterministic Method for Automatic Visual Grading of Seed Food Products To cite this version?:, in: 4th Int. Conf. Pattern Recognit. Appl. Methods, Lisboa, Portugal, 2015: pp. 1–6.

21. P. Dubosclard, S. Larnier, H. Konik, A. Herbulot, M. Devy, Automated visual grading of grain kernels by machine vision, in: Twelfth Int. Conf. Qual. Control by Artif. Vis., 2015: pp. 1–8. https://doi.org/10.1117/12.2182793.

22. P. Potter, J.M. Valiente, G. Andreu-García, Automatic Visual Inspection of Corn Kernels Using Principal Component Analysis, (2015).

23. P.A. Belan, S.A. de Araújo, J.C.C. Santana, UM SISTEMA DE ANÁLISE DE IMAGENS PARA CLASSIFICAÇÃO AUTOMÁTICA DE GRÃOS DE FEIJÃO BRASILEIRO, in: Proc. {XXXVI} Iber. Lat. Am. Congr. Comput. Methods Eng., ABMEC - Brazilian Association of Computational Methods in Engineering, 2015: pp. 1–7. https://doi.org/10.20906/CPS/CILAMCE2015-0772.

24. S.A. Araújo, J.H. Pessota, H.Y. Kim, Beans quality inspection using correlation-based granulometry, Eng. Appl. Artif. Intell. 40 (2015) 84–94. https://doi.org/10.1016/j.engappai.2015.01.004.

25. S.A. Araújo, W.A.L. Alves, P.A. Belan, K.P. Anselmo, A Computer Vision System for Automatic Classification of Most Consumed Brazilian Beans, Lect. Notes Comput. Sci. 9475 (2015) 45–53. https://doi.org/10.1007/978-3-319-27863-6.

26. P.A. Belan, S.A. Araújo, W.A.L. Alves, Image Analysis and Recognition, Springer International Publishing, Cham, 2016. https://doi.org/10.1007/978-3-319-41501-7.

27. P.A. Belan, M.M.A. Pereira, S.A. Araújo, W.A.L. Alves, Abordagem Computacional para Classificação Automática de Grãos de Feijão em Tempo Real, in: SeTII 2016, São Paulo, Brasil, 2016: pp. 1–4.

28. H. Zareiforoush, S. Minaei, M.R. Alizadeh, A. Banakar, Qualitative classification of milled rice grains using computer vision and metaheuristics techniques, J. Food Sci. Technol. 53 (2016) 118–131. https://doi.org/10.1007/s13197-015-1947-4.

29. P.J. Ramos, F.A. Prieto, E.C. Montoya, C.E. Oliveros, Automatic fruit count on coffee branches using computer vision, Comput. Electron. Agric. 137 (2017) 9–22. https://doi.org/10.1016/j.compag.2017.03.010.

30. S. Bhat, S. Panat, N. Arunachalam, Classification of rice grain varieties arranged in scattered and heap fashion using image processing, in: Ninth Int. Conf. Mach. Vis. (ICMV 2016), Nice, França, 2017: pp. 1–6. https://doi.org/10.1117/12.2268802.

31. P.A. Belan, R.A.G. De Macedo, M.A. Pereira, W.A.L. Alves, S.A. Araújo, A Fast and
Index Terms

Computer Science  Embedded Systems

Keywords

Embedded System; Raspberry; Computer Vision; Visual Inspection; Bean