

***ImageInspector* : a multipurpose system for agri-food products**

Gianfranco Venora, Oscar Grillo, Rossella Saccone, Concetta Ravalli

*Stazione Sperimentale di Granicoltura per la Sicilia, Buganvillea 20, Caltagirone, Italy
Corresponding author: venora@granicoltura.it*

Abstract: *Results are presented on the development of a low-cost image analysis system which is helpful in many fields of the agri-food chain.*

Specific image analysis issues were approached and solved by developing specific macros for routine analysis.

Some case studies are reported. Lentil varieties and landraces identification; Italian bean landraces identification and wild species characterization and identification, using image acquired with a flatbed scanner. The obtained data were statistically elaborated to carry out classifiers that used the linear discriminant analysis algorithm for identification purpose.

Basic points of durum wheat chain, such as the grain raw material producing, its milling and semolina yield and processing in bread and pasta, were the subject of qualitative-quantitative evaluation, using the same image analysis technique.

In particular, a robust Bayesian classifier integrated in the durum wheat grain evaluation procedure was carried out, it correctly identifies 99.33% of vitreous kernels, 94.83% of starchy, 96.46% of the piebald and 97.50% of shrunken kernels, moreover it is able to estimate the percentage of semola yield.

The semola quality was evaluated, by means of black and bran points count. The quality of end products such as pasta, was explored for the presence of black points, which according to Italian law, they should not be present. Also bread sliced was evaluated, objectively, by means of image analysis techniques.

These and other applications, that should increase in the future, have stimulated the development of the ImageInspector, a marketable prototype which is at the same time user-friendly, portable and cheap, because the images are acquired with camera or scanner.

1 Introduction

Image analysis is proving to be an objective investigation tool, in particular in the cereal food chain, for the quality characterization and defects detection.

Many small and medium industries in the Agri-food chain, while estimating important the use of systems based on imaging technology, they not found available on the market, systems able to perform those specific quantitative and qualitative analysis at low costs, with no accuracy lost in results.

Even the PGI, PDO European Trademark consortia, could be safeguard their precious products, with this quick, reliable and cheap technology.

For many years in our laboratories we advantage of image analysis technology, to develop applications or *macros* for routine analysis in various fields (GRILLO *et al.* 2007, VENORA *et al.* 2007, BACCHETTA *et al.* 2008, MATTANA *et al.* 2008, VENORA *et al.* 2008, DOUST *et al.* 2009, SYMONS *et al.* 2009, VENORA *et al.* 2009a, VENORA *et al.* 2009b). Some applications, tested in the laboratory have proved very useful and usable at industrial level. For this reason, we were encouraged to develop a system that could accommodate different applications for different uses.

ImageInspector prototype, developed at Stazione Sperimentale di Granicoltura, could be the image analyser for visual assessment, suitable for small laboratories as storage centers, seed industries, mills, pasta factory and bakeries, moreover it could be used in other sectors of the agri-food for raw or processed materials.

2 Materials and methods

ImageInspector consists of hardware components and software for the *macros* management.

A PC or a Notebook with a Microsoft® Windows operative system XP or later. The image acquisition equipment can be a professional flatbed scanner with or without a trans-illuminator cover, or a digital camera integrated in a black-room for excluding environmental light and/or placed on a trans-illuminator table, depending of the user needs. The image acquisition hardware can be exchanged according to the changing preferences or tasks.

All applications of image analysis, the macros that can be used by *ImageInspector*, have been developed using the library of KS400 Image Analysis (Zeiss, Germany), with its proprietary language Klic. The macros can be used as stand alone programs with the software KRun (Zeiss, Germany), it contains in background the entire library of KS400, but does not allows neither editing not developing of applications or macros.

3 Results

Figure 1 shows a view of *ImageInspector*, in the middle a Notebook with KRun Software running the macro *Semola. mcr*. In the left the camera mounted on the top of a black-room for excluding environmental light, with a window to place the samples, and a

5.7" TFT liquid crystal screen monitor for viewing the samples before acquiring, in this case a Petri dish filled with semola for black and bran points count.

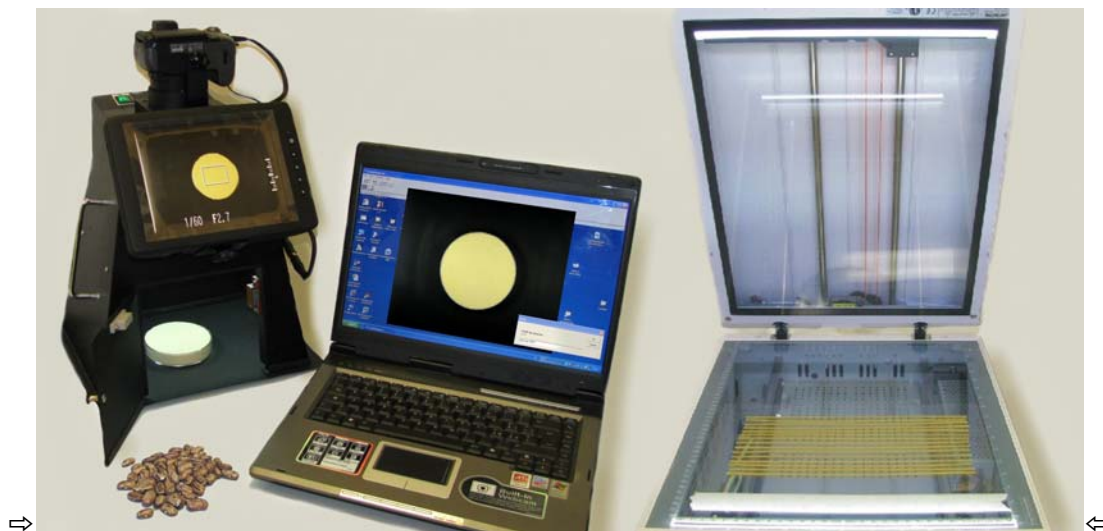


Figure 1: *ImageInspector*

On the right, a professional flatbed scanner with a trans-illuminator cover, ready to run the macro *SpaghettiSpeckCount.mcr*. To see and count the specks on spaghetti strands, it is necessary to acquire transilluminated images.

ImageInspector was already proved to be quick, reliable and consistent in image acquisition and analysis with different macro developed to solve specific problem.

Using the macro *Lens.mcr*, eight lentil varieties and landraces were correctly identified, in the training set (99.80%) and test set (97.10%) respectively (VENORA *et al.* 2007).

Using the macro *Bean.mcr*, fifteen Italian bean landraces were correctly identified in the training set (99.00%) and test set (98.20%) respectively (VENORA *et al.* 2009a).

The macro *Wild.mcr*, was developed to create a database of seeds morfo-colorimetric traits, for the characterization of autochthonous germplasm in entry to the bank and the realization of statistic classifiers for the discrimination of genera and species, within many botanical families. The obtained data, were statistically elaborated to carry out classifiers using, later off-line, the linear discriminant analysis algorithm for identification (SPSS statistic package). Such classifiers showed a performance between 74.3% and 96.4% (BACCHETTA *et al.* 2008). In addition, for the genus *Astragalus*, it was possible to elaborate a classifier able to identify very similar taxa of a species complex, obtaining a performance between 83.7% and 100% (MATTANA *et al.* 2008).

One important problem solved with *ImageInspector* was the Vitreosness amount determination on durum wheat kernels at the storage centers. In particular, a robust Bayesian classifier integrated in the wheat grain evaluation procedure was carried out, it cor-

rectly identifies 99.33% of Vitreous kernels, 94.83% of Starchy, 96.46% of the Piebald and 97.50% of Shrunken kernels, moreover it is able to estimate the percentage of semola yield (VENORA *et al.* 2009b).

The macro *Semola.mcr* allows to evaluate the semola quality by means of black and bran points count, they affects the quality of end products such as pasta (**Figure 1**). The macro *SpaghettiSpeckCount.mcr* is a quick and objective imaging method to count the dark specks in spaghetti strands, acquired using a flatbed scanner with a transilluminator cover (**Figure 1**). The method simultaneously measured individual speck size and colour and determined the overall color of the spaghetti product. According to Italian law, any specks should not be present (VENORA *et al.* 2008, SYMONS *et al.* 2009).

Bread, such as pasta, is a very important end product of cereal chain. The macro *Bread.mcr* allow to acquire and measure bread slices, giving an objective evaluation of texture, and its relationship with bread constituents, for example flour type (wheat varieties), ingredients kind and amount, such as leaven or sourdough (GRILLO *et al.* 2007, DOUST *et al.* 2009).

4 Conclusions

The applications here reminded, have stimulated the development of the *ImageInspector*, a marketable prototype which is at the same time user-friendly, portable and cheap, because the images are acquired with camera or scanner. Moreover, many new applications or improvement of the already developed ones coming soon.

To facilitate a wide distribution of *ImageInspector*, whose rapid implementation can be achieved only through co-operation between different institutions operating in different fields, the authors are open for and interested in possible collaborations through the sharing of knowledge. Moreover the Stazione Sperimentale di Granicoltura is open to collaborate with factories to merchandise *ImageInspector*.

References

- BACCHETTA G., GRILLO O., MATTANA E. VENORA G. (2008): Morpho-colorimetric characterization by image analysis to identify diaspores of wild plant species. *Flora* 203 (8): 669-682
- Carl Zeiss Vision. (1998): KS-400 image analysis library. Version 3.0. Oberkochen, Germany
- DOUST M.A., RIZZO B., GRILLO O., PECORINO B. VENORA G. (2009): Sourdough effects on the crumb texture and shelf-life evaluated with dynamometer and Image analysis measurements in the Dittaino Pagnotta P.D.O., a durum wheat bread produced by a Sicilian bakery industry. In Proceedings of the CIGR Section VI International Symposium on Food Processing, Monitoring Technology in Bioprocesses and Food Quality Management. ed. D.W. SUN, Potsdam, Germany 31 August - 02 September 2009

- GRILLO O., ORLANDO A., RAIMONDO I., VENORA G. (2007):** Fingerprinting del pane: tecniche di analisi d'immagine per la caratterizzazione, tracciabilità e rintracciabilità. *Tecnica Molitoria*, 58 (9): 1-14
- MATTANA E., GRILLO O., VENORA G., BACCHETTA G. (2008):** Germplasm image analysis of *Astragalus maritimus* and *A. verrucosus* (subgen. *Trimeniaeus*). *Anales del Jardín Botánico de Madrid* 65 (1): 149-155
- SPSS. (1999):** SPSS Application Guide Base10.0. Chicago, Illinois, USA: SPSS Inc
- SPSS. (2006):** SPSS for Windows. Version 15.0. Chicago, Illinois, USA: SPSS Inc
- SYMONS S.J., VENORA G., VAN SCHEPDAEL L., SHAHIN M.A. (2009):** Measurement of spaghetti speck count, size and colour using an automated imaging system. *Cereal Chemistry* 86(2): 164-169
- VENORA G., GRILLO O., SACCONI R., RAVALLI C. (2008):** - Speck evaluation on commercial spaghetti using an imaging system. in: *From Seed to Pasta : The Durum Wheat Chain - International Durum Wheat Symposium*. Bologna Italy, June 30 - July 3 Bologna, Edizioni Avenue Media, Milano
- VENORA G., GRILLO O., SHAHIN M.A., SYMONS S.J. (2007):** Identification of Sicilian landraces and Canadian cultivars of lentil using image analysis system. *Food Research International*, 40: 161-166.
- VENORA G., GRILLO O., RAVALLI C., CREMONINI R. (2009):** Identification of Italian landraces of bean (*Phaseolus vulgaris* L.) using an image analysis system. *Scientia Horticulturae* 121: 410-418
- VENORA G., GRILLO O., SACCONI R. (2009B):** Quality assessment of durum wheat storage centres in Sicily: Evaluation of Vitreous, Starchy and Shrunken Kernels using an Image Analysis System. *Journal Cereal Science* 49 (3): 429-440