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Digital Food Photography: dietary surveillance and beyond

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Abstract

The method used for creating a database of approximately 20,000 digital images of multiple portion sizes of foods linked to the USDA's Food and Nutrient Database for Dietary Studies (FNDDS) is presented. The creation of this database began in 2002 and its development has spanned 10 years. Initially the images were intended to be used as a kid-friendly aid for estimating portion size in the context of a computerized 24-hour dietary recall for 8-15 year old children. In 2006, Baylor College of Medicine, Westat, and the National Cancer Institute initiated a collaboration that resulted in the expansion of this image database in preparation for the release of the web-based Automated Self-Administered 24 Hour Dietary Recall (ASA24) for adults (now also available for use by children – ASA24-Kids). Researchers in the US and overseas have capitalized on these digital images for purposes including, but not limited, to dietary assessment.

Keywords: digital images; portion size assessment; dietary surveillance; technology aided dietary assessment

1. Introduction

The Food Intake Recording Software System (FIRSSt) [1] was originally developed as a computer-based, self-assessment tool to collect dietary information on number of servings of fruit and vegetables among school-age children. The success of this program, encouraged our team of nutritionists at the Children's Nutrition Research Center (CNRC) to enhance the application by expanding the food and nutrient database and incorporating one of the top eleven technologies of the previous decade: digital photography [2] The idea was that the incorporation of digitally produced portion size images could

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potentially facilitate children's portion size estimation. However, to produce a large number of standardized digital images with minimal effort, a standardized tool was needed and the Food Photography System (FPS) was such tool.

The FPS made it possible to produce approximately 4000 digital images representing the food types, forms and range of portion sizes frequently reported by children in the Continuing Survey of Food Intake by Individuals 1994-1996-1998 (CSFII 94-96, 98).

In February 2006, the Exposure Biology Program, one of the components of the Genes, Environment and Health Initiative (GEI) was launched, thus providing the first funding opportunity to move the food photography project forward. However, it was the partnership with the National Cancer Institute and Westat, which permitted the expansion of the digital image database to accommodate the requirements of a self-administered tool for both adults and kids, the web-based Automated Self -Administered 24 Hour Dietary Recall (ASA24) and ASA24-Kids [3].

2. Methods

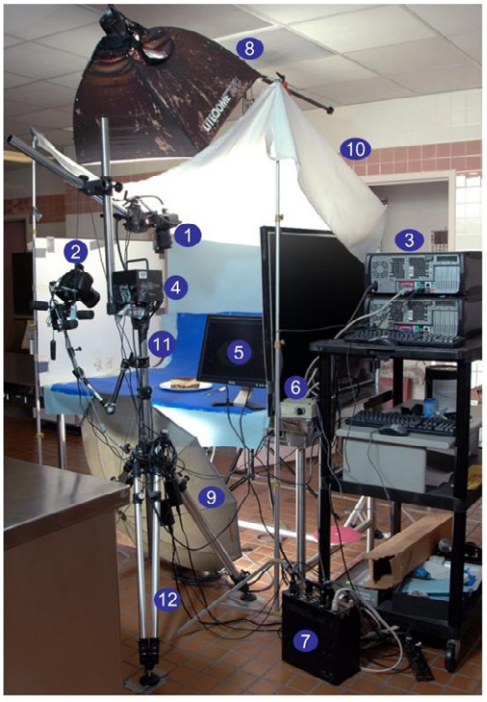
2.1. Food Photography System (FPS)

The main goal of the FPS was to produce high quality, high resolution digital images with minimal technical expertise and limited budget. To achieve this goal, the system had to be able to meet the following requirements:

- Produce properly exposed images with sharp detail
- Allow to easily obtain aerial and angled (42º) exposures of the foods
- Be simple to operate: require minimal manipulation of the cameras with only sporadic calibrations by a professional photographer
- Allow for quick, "on the job" quality control of the exposures
- Allow the storage and transfer of images to and from dedicated PCs without manipulation of the secure digital card (SD)

2.2. System design and components

A front view of the main components of the FPS is shown in Figure 1 and the two angles of exposure are illustrated in Figure 2. Of the two cameras shown in Figure 2, the one at the top captures aerial views, is placed at a distance of 86.36 cm (measured from the focal point to the film plate) and is set at an angle of 5º from the vertical plane to eliminate reflections of the camera on the images. The second camera, placed on the left side, captures angled views at a distance of 91.44 cm (measured from the focal point to the film plate) and is set at an angle of 42º above the horizontal, considered to be the average angle of viewing for a subject seated at a dining table [4].



1. Aerial Nikon F80 camera with 28-125mm zoom lens and AC power supply, electronic cable release and flash sync cable
2. Angled Nikon F80 camera with 28-125mm zoom lens and AC power supply, electronic cable release and flash sync cable
3. Windows driven PCs, one per camera with Nikon Camera Control Pro software for direct computer control and capture via USB cables
4. Kinex viewfinder projector
5. 15" LCD monitor
6. Computer monitor switcher
7. Comet studio lighting control and power supply
8. Comet flash head with a large soft light box
9. Comet flash head with a reflective umbrella
10. Backdrop stand, paper backdrop, diffusion fabric, light stands and white mount board
11. Chroma-key blue painted backdrop
12. Heavy tripod with attached second mount

Fig.1. FPS system components

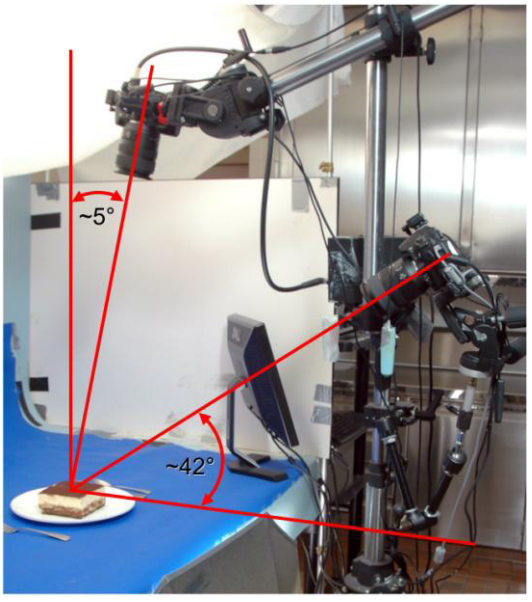


Fig.2. Side view of the FPS showing camera angles

2.3. Lighting and background

All foods are photographed in a light booth constructed upon a kitchen preparation table. The booth is large enough to allow the placement and retrieval of the plate/bowl without disturbing the set-up. The booth dimensions are: 138 cm width, by 122 cm height and 91.8 cm depth.
Light is supplied by two flash heads with integrated modeling lamps that provide continuous lighting for composing the image. The main light is a large light box suspended above the place setting and slightly behind the top camera. The light emanating from the lamp is softened through a layer of diffusion material that forms the top of the booth. Fill light comes from an umbrella reflector positioned under the table. The left and right sides of the booth are made of white matte board.

A stand supports a paper backdrop that gradually curves from the back of the booth to cover the table surface. It is coated with Chroma-key blue paint, thus allowing graphic artists to easily drop out the background of the picture and replace it with one of their own.

2.4. Image capture and storage

Each camera connects to its own PC via a USB cable. The software installed on each of the PCs controls the cameras remotely, enabling the viewing of the images on a 15" LCD monitor. The monitor display allows the operator to view the images as soon as the shutter is released. The images captured by the top and side cameras are stored on different PCs. Upon completion of the photo capturing session, these images are transferred to a network location for safe-keeping and image cataloguing.

2.5. Image quality and standardization

Figure 3 shows a thumbnail size picture representing the aerial and angled view exposures of a "¾ cup of cheese-filled manicotti with tomato sauce" generated by the FPS. Both cameras are set to capture JPEG files of the highest quality and size (3 megabytes each). Images are extremely detailed and can be used for all types of output ranging from screen viewing to quality printing. End users have the flexibility to choose which way they want to process the images for their own specific needs.

Image standardization in the FPS is achieved by comparing images obtained against reference images of the place setting captured and stored on the computer hard drives for calibration purposes. Additionally, minute registration marks are strategically placed on the backdrop to facilitate the realignment of the plate and/or cutlery if a displacement occurs when the plates with food are moved in and out of the booth during a photo capturing session.

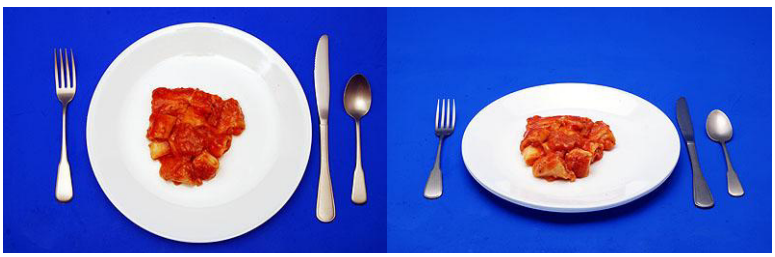


Fig.3. Aerial and angled views of ¾ cup of cheese filled manicotti with tomato sauce

Another way to achieve standardization is to use the same type of plates and bowls. Baylor has consistently used Corelle® Winter Frost white plates (10.25" dia) and 18-oz Corelle® Winter Frost soup and dessert bowls (6.25" top dia). To avoid disturbing the place setting during image capturing, we use a base plate of the same type and size as a place holder.

2.6. System operation

A system like the FPS requires minimum technical skill to be operated successfully. However, tasks such as food selection, acquisition, preparation, weighing and/or measuring of the food items to be depicted on the images according to a detailed protocol are better done by a professional with a background in food and nutrition (dietitians, dietetic technicians, or advanced food science students are the best operators).

3. Results and Discussion

To date, the FPS has generated about 20,000 standardized portion size images of foods, in both aerial and angled views. Half of the images produced have been incorporated in the ASA24 web-based application [5]. The protocol used to capture portion size images for ASA24 required that all images be linked to an eight-digit FNDDS code and to a portion size descriptor and gram weight value. This feature sets the image database apart from others, and has resulted in a number of collaborations with researchers both in the US and abroad.

Examples of this collaborative work include:

- A researcher from Denmark, who included a subset of our digital images to be used as portion size aids in a self-report tool for 9-11 year old Danish children, the Web-based Dietary Assessment Software for Children known as WebDASC [6]
- A researcher from Pennington Biomedical Research Center, LSU, who is using the images produced by the FPS as a standard or reference against which to compare before and after pictures captured by study participants using a smart phone [7]
- A researcher from the University of Washington, who used a subset of the digital images in video games for diabetes nutrition education
- A researcher from Indiana State University who used our standardized images to appropriately scale the digital images they had produced in their lab

In addition to the above mentioned research applications, portion size food photography could play a role in interventions aimed at helping consumers better cope with an environment known to promote "portion distortion" [8][9]. In this context, portion size images alongside nutrition information, could potentially have a positive impact, by providing a normative benchmark [10] of how much is appropriate to eat (see Figure 4) or drink, and overriding the influence of "marketing " driven cues such as package size, or "counseling" driven rules such as number of servings.

To create and maintain an image database of the proportions above described requires a considerable investment of time and resources. By making the image database freely available to other scientists and/or educators that request the permission to use it by contacting the National Cancer Institute (http://riskfactor.cancer.gov/tools/instruments/asa24/resources/contact.html) we seek to have the best possible return for such an investment.

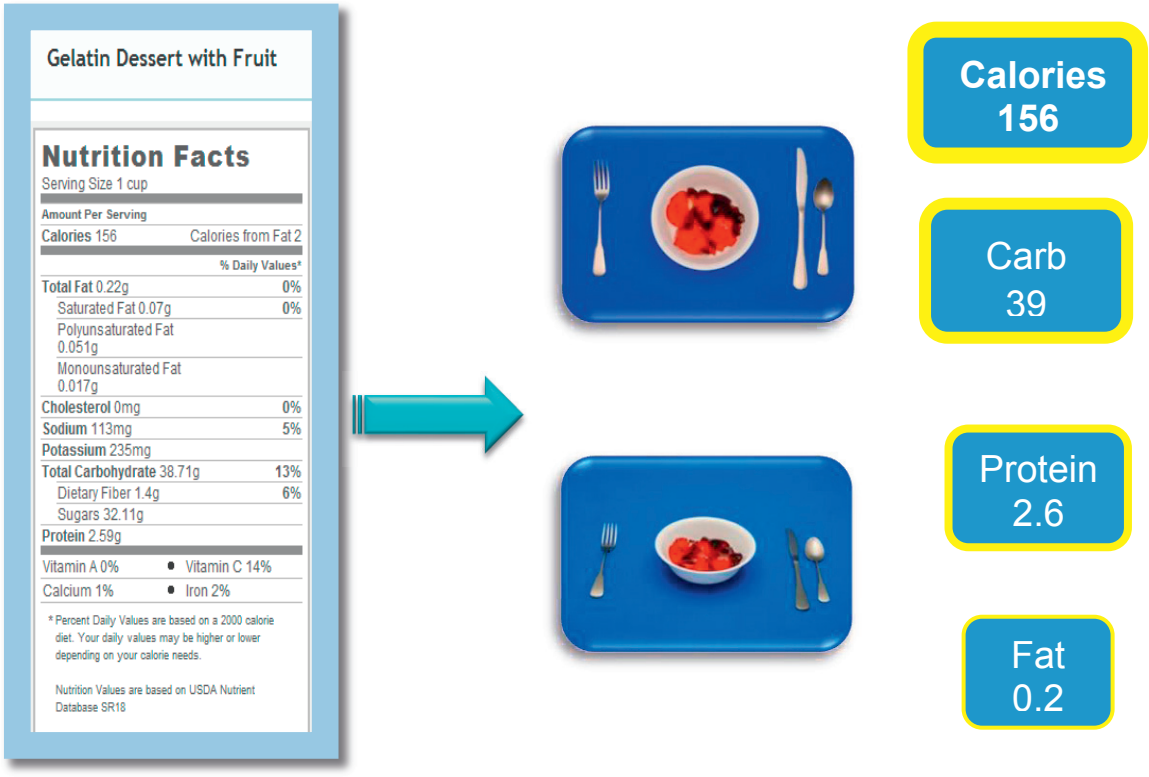


Fig 4.Nutrition facts: using portion size photography as a visual cue

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