Kinect Based System Applied to Breast Cancer Conservative Treatment

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PROVISIONAL VERSION

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<td>3D</td>
<td>Tri-Dimensional / Three-Dimensions</td>
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<td>BC</td>
<td>Breast Cancer</td>
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<td>BCCT</td>
<td>Breast Cancer Conservative Treatment</td>
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<td>BCCT.core</td>
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<td>BSA 1.0</td>
<td>Breast Shape Analyzer 0.1</td>
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<td>GLOSH</td>
<td>Gradient Location and Orientation Histogram</td>
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<td>High Resolution</td>
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<td>IBP</td>
<td>Iterative Back Projection</td>
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<td>LESH</td>
<td>Local Energy based Shape Histogram</td>
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<td>Low Resolution</td>
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<td>MAP</td>
<td>Maximum a Posteriori</td>
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<tr>
<td>mm</td>
<td>Millimetres</td>
</tr>
<tr>
<td>POCS</td>
<td>Projection Onto Convex Sets</td>
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<tr>
<td>QoL</td>
<td>Quality-of-Life</td>
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<tr>
<td>RBF</td>
<td>Radial Basis Machine</td>
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<td>RMS</td>
<td>Root Mean Square</td>
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<td>SIFT</td>
<td>Scale-Invariant Feature Transform</td>
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<td>SR</td>
<td>Super Resolution</td>
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<td>SURF</td>
<td>Speeded-Up Robust Features</td>
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1. Introduction

Breast Cancer (BC) is a malign tumour which develops within mammary tissue. It is the most common tumour affecting women, presenting a ruling impact on women physical image. The survival expectancy for the disease is rising and estimated to exceed 80% for a period of 10 years, so women are expected to cope with the treatment consequences for long years. Thus, the importance of achieving good aesthetic outcome in treatment is crucial, although it is often recognized that is not the generally achieved. For the improvement in treatment techniques, the existence of general measurements of the cosmetic outcome has become a deficit, vastly due to lack of standard methods that objectively qualify outcomes. So there is a strong need to replace subjective evaluation with objective and reproducible methods. A validation tool to enhance or replace human evaluation is desirable, both easy to deploy and to use.

Breast Cancer Conservative Treatment (BCCT) is nowadays the standard procedure to treat breast tumours. Women who undergo conservative treatment place a premium on breast conservation and aesthetics, and more and more women are deciding to treat their breast cancers without permanent loss of the breast. Conservative Treatment employs techniques to preserve the breast by combining the removal of cancerous tissue by surgery with posterior complementary therapy. Posterior therapies are accomplished by radiotherapy or by medication such as chemotherapy or hormonal therapy. These post operatory therapies are essential for the complete eradication of the tumour or to reduce incidence of recurrence. Also, reconstructive procedures of affected areas may take place alongside or after the cancer-removing surgery.

BCCT has shown results of similar survival rates on patients comparing to other treatments like mastectomy [1], but providing better aesthetical outcomes. A good aesthetical outcome improves patient’s Quality-of-Life (QoL) since they usually cope with the results for an extended period of time. The cosmetic result depends on several factors from diagnosis to tumour characteristics, patient’s response to treatment, and the techniques applied in the treatment. The combination of these factors contributes to the sparse outcomes of cosmetic results. Then, its evaluation is fundamental to adapt key variables that would cause an improvement over surgical techniques and standard protocols, that are expected to have higher influence over cosmetic result than posterior therapies [2]. Such documentation would serve as guidelines to surgical procedures and guarantee quality assessments [3].

The assessment of the cosmetic result is usually performed by one or more observers, through visual inspection of the patients or their representative photographs [4]. Inheritably human decisions are subjective due to complex factors and final evaluation decision is, therefore, also subjective. Usually the evaluators grade the aesthetical result by comparing measurements between the treated and non-treated breast, using one of several scales found in the literature. The most common evaluation scale was introduced by Harris in 1979 [12] and is
2 Introduction

based on a classification of the cosmetic result in four classes: excellent, good, fair, and poor. The use of different evaluation scales and the fact that some clinicians who take part in the procedure are also evaluators, make the aesthetical result interpretation rather vague. It is then, difficult to compare assessments made from different panels of observers since their level of agreement is usually low or moderate, comprising a low reproducibility in results [5].

By disparities in cosmetic assessment due to lack of standard methods, clinicians faced adversities in development or refinement of procedures to globally improve aesthetical results, since some could weight key variables differently. To overcome poor reproducibility of cosmetic assessment some objective methods were introduced, consisting in measurements of identifiable points from patients photographs [6,7]. Other groups have complemented or correlated asymmetry measurements with a sum of individual scores of subjective and objective indices [5, 8]. In 1985, Pezner et al. [9], proposed the first objective assessment measurement: the Breast Retraction Assessment (BRA), to measure the retraction of the treated breast regarding the non-treated one. Further measurements were proposed based on breast asymmetry, but most were result of combination with subjective assessments from observers. Therefore, the lack of standardized evaluation of cosmetic outcomes continued to persist. To overcome that subjective barrier, there was a need to reach an assessment that is objective and reproducible so clinicians can use and validate others assessments.
2. BCCT.core as objective tool

The Visual Computing and Machine Intelligence (VCMI\(^1\)) has developed the software entitled Breast Cancer Conservative Treatment.cosmetic results (BCCT.core) (Fig. 1) [10], introducing a valuable objective tool for the BCCT aesthetic evaluation result.

![BCCT.core interface](image)

Fig. 1 - BCCT.core interface

This software is a semi-automated, objectively and reproducible tool, for the assessment of the aesthetic result based on the comparison of the treated and non-treated breasts, in frontal digital images from patients subjected to BCCT. The system is capable to extract features from the patient’s photographs such, breast asymmetry, skin colour change and scar visibility [11]. To achieve this, the user must manually identify breast endpoints, nipple position and sterna notch position. Afterwards, it is capable of detecting breast contours and to automatically extract features related to the aesthetical outcome. The output of the evaluation is categorized according to Harris scale (excellent, good, fair and poor). The final objective evaluation is a summary of the overall aesthetic result, based on a Machine Learning algorithm [12], allowing the identification of which key factors influence the outcome of the treatment. It is, then,

\(^{1}\) http://vcmi.inescporto.pt
possible to use this system as a mean to improve current treatment techniques and to compare assessments of different work teams.

2.1 Previous Improvements

At the present moment BCCT.core only uses frontal images of patients and is not totally automatic. This means that limited information is available on the breast shape, and final aesthetic evaluation result slightly depend of user inputs. In order to introduce more available information on breast shape, the workgroup has made essays to enrich the system’s evaluation. On automatic breast contour detection [13], improved previous contour algorithm [14], or by incorporating prior shape information on the detection algorithm [15] (Fig. 2).

**Fig. 2 – Contour results from Cardoso et al. [12]**

Furthermore, in [16] proposed a method to automatically find external endpoints through the formulation of the breast contours. An often suggested improvement to BCCT.core was the interpretability of the model on which the system uses to predict overall cosmetic result. This was due to the need to understand how the model operates and the limited knowledge that clinicians have from relation between final result and feature inputs. In [17], the authors consider a linear Support Vector Machine (SVM) and Decision Trees to substitute the SVM classifier with a Radial Basis Function (RBF) fitted in BCCT.core at the time. Linear models for classification divide the input space into decision regions which are linear to the determined input, so the decision space is a simple weighted sum of input features. Therefore is simple to give higher weights to features with more relevant impact in the decision process. The authors conclude that the use of a linear model onto BCCT.core will increase its interpretability and provide validation and trust on the use of the system. In order to verify whether the lateral measures represented an increase of valuable information to improve overall assessment, the work presented in [18], provided the introduction of lateral information from patient’s side-view. From its study the authors concluded that improvements were not significant, although, it is added that the use of more robust models or tri-dimensional 3D models would help to achieve better performance in overall cosmetic assessment.
3. 3D data on BCCT evaluation

BCCT.core software tool has proven that is capable of being improved by providing more measures or to add dimensionality to the ones made. However female breast is (3D) and its boundaries and volume are difficult to attain. 3D data can improve feature acquisition by producing more measurements thus optimizing the evaluation of the aesthetical result. Some research groups have made attempts to use 3D technology to capture the volumetric information and surface modelling [19-21]. Although, the more interesting approaches have been performed by Losken et al. [22-24] and Catanuto et al. [25-28]. Losken et al. used a 3D camera to quantify the cosmetic result of BCCT by an objective technique. With their system, they compare the treat and non-treated breast by analyzing the surface and volume differences. Through a software program, they later analyse the level of asymmetry between the breasts using a root mean square (RMS) calculation, by mirroring on side of the patient and superimpose it with the original image. On the other hand, Catanuto et al. used a 3D laser scanner making use of anatomical landmarks identified by surgeons to develop the Breast Shape Analyzer 0.1 (BSA 0.1) software. By using limited well-defined anatomical endpoints, identified and selected by surgeons, the software provides an objective and quantitative measurements (Fig. 3) [25].

![Application example from Farinella et al. [25]](image)

The technique employed divides the breast in 4 anatomic subunits to extract several measures that can be extrapolated onto a 3D model data set. The data was collected with a commercial laser scanner from volunteers scanned in three different occasions while sited on a chair with their backs tilted 45 degrees and rotating them to the left and right. The main drawback of this approach is the patient’s uncontrollable physiological movements, which posed a problem when merging scans. Further, Catanuto et al. [26], suggest a set of parameters to characterize the breast shape, such surface, distance and angles measurements; curvature properties and symmetry analysis. Employing the same acquisition method and system to evaluate these set of parameters, the authors express that the angle calculations and the graphic
depiction of the breast “curvature” are the most interesting and innovating results. The former, the “di-vergence angle”, gives a perspective on the point of view of the patient’s own breasts (Fig. 4); and the later introduces a representation on the breast based on a colour map to express flat regions and curvature (Fig. 5). The authors conclude that the colour based curvature representation can replace volume terminology, as curvature can be expressed either with colours and its degree by coefficients.

Further, Catanuto et al. [27] present estimation and reconstruction of the breasts using an optoelectronic tracking system, which allows real-time breathing artefact correction [28] and surface patch (fusion). By applying their technique they obtain a graphic depiction of the curvature of the thoracic surface. Although interesting results come from these techniques they all show a deficit in using specialized hardware, software and personnel.

Isogai et al. [19] developed a 3D imaging system using laser light scanning to perform a quantitative analysis. By mirroring the normal breast onto the reconstructed breast, the system gives an evaluation based on breast symmetry, volume and shape. By registering the volumetric differences through radiotherapy, Bert et al. [29], produced daily surface models. The described system registers the transformations based on the collected data and determines the rigid-body transformation. Balaniuk et al. [30] also developed a 3D imaging tool to simulate the cosmetic outcome. The system uses virtual reality combined with soft tissue modelling methods, and the authors emphasise the importance of the tool for both patients and surgeons that through simulation can make more informed decisions (Fig. 4).
Furthermore, the use of 3D models can improve medical practice, such as surgical techniques and skills, as the software can be improved to have embedded simulation. Surgeons can boost their performance and techniques onto breast intervention procedures and also provide anticipation of surgical options and outcomes. Tepper et al. [21] provide, in their work, an overview of 3D breast photography and how they pose a potential establishment of a standardized system for breast analysis. They introduce a new concept “mammometrics”, 3D based breast measurements that can be used to guide operative planning and analyze surgical results objectively. This will help patients to build a better understanding and informed choice of surgical outcomes. Such feature’s gains increases the relevance of using 3D information in evaluating aesthetic results. Although the advantages of using a 3D model are immense its acquisition must be practical (performed by the clinicians themselves), and without using expensive equipment or requiring specialized personnel. Also the acquisition step should be fully autonomous or require minimal input from the user. Consequently the need of simple and low cost solution that could be fit as a computer peripheral to complement the software system.

3.1 BCCT.core using 3D data

Oliveira et al. [31] conducted a study and development of low-cost and ease of operation solutions to gather a 3D model of a female torso. They first implemented a reconstruction algorithm from two uncalibrated views through epipolar geometry gathering acceptable results. The second implementation using a disparity map acquired by a Kinect™ device provided very satisfactory results, mainly the tests with real patients. The device allowed to detect volumetric differences, and the results were very similar to reference measures manually performed by the physician. On the 3D model reconstruction from two uncalibrated views, Soares [32] came to conclude that state-of-the-art algorithms for stereo matching failed to provide a proper reconstruction. The unsuccessful results were given to the high ambiguity that is found on the images that the project works on, and to lack of poor confident matching in image areas. It is concluded that further search or development is needed to suit the project’s needs.

As verified in [31, 33], with the use of the Kinect™ motion sensor device is possible to generate a disparity map to use in a future 3D mesh construction. This device comprises the requirements of being both low-cost and user-friendly. With the gathered 3D data is possible to
produce models that can be viewed from different angles and produce more measurements based on that data that is inaccessible from patient’s photographs, alone or combined. This would bring BCCT.core valuable measurements to complement its overall aesthetical assessment of breast interventions.

Fig. 7 - Kinect acquisition from Oliveira et al. [33] (Left – Photograph acquired with normal camera; Right – Disparity map acquired with Kinect™ device)
4. Objectives

In order to contribute to previous developments achieved by the workgroup, preliminary studies will be carried out in order to comprehend the necessary extension of upgrades to BCCT.core. Namely the introduction of 3D data sets into the evaluation model and to understand its requisites, following the tendency of recent contributions to the system. 3D data acquisition and the pursuit of a fully autonomous tool lead to the necessity of achieving further contributions in order to have greater autonomy by the software system.

The aim with this project is to contribute with the enrichment of the data collected from the Kinect™ and use it to come to new 3D features definitions. Automatic 3D feature definition and extraction will allow a more complete evaluation of the aesthetical outcome. By consequence, the system’s evaluation quality and consistency is increase. Although, the main drawback is the low resolution of depth maps captured, it evidences the need to research and deployment of resolution enhancement before further processing, the initial objective of this research.

With these contributions and by the use of 2D+3D information, we expect to improve the performance of the current evaluation. Finally, it is important to compare it to the standard subjective evaluation performed by medical experts and using objective evaluations, namely with BCCT.core to validate the new model.
5. Kinect sensor as a tool for aesthetic evaluation of BCCT

The Kinect™ is a motion sensing device hands free game controller for X-BOX 360™ video game console. The device has one RGB camera and one infrared based depth sensor, both capable of captures at video rate and under any ambient lighting conditions with 640x480 pixels. This hardware device is fairly recent and its use has began to widespread in the visual and imaging computer processing community due to its low cost and applicability potential. Using its sensors the device is capable of rendering a disparity map of the scene either in colour or in gray scale, on which image processing is applied to recover the 3D data. The collected data from the depth sensor with its representation in pixels cannot be transferred directly to real metric distances. However the information present in disparity maps is consistent, therefore comparisons between breast asymmetries or other operations between pixels can be performed, safeguarding the results produced.

By providing 3D data, in the form of disparity maps, it allows the definition of new sets of data inaccessible up to now. Such vital information, as volumetric information, can render the extraction and qualification of new measurements possible to incorporate into the existing BCCT.core model for aesthetic objective evaluation. As demonstrated by Oliveira et al. [31, 33] 3D data extraction using the Kinect™ has great potential to introduce volumetric information into BCCT.core system and experiments yielded similar results compared to reference measurements manually performed by a physician. Therefore the software would be greatly improved by the incorporation of 3D data, improving overall aesthetic assessment and for future developments such breast surgery simulations.

Novel approaches on human or scene scanning have been performed using the Kinect™ sensor device. Using the colour images combined with the depth maps rendered by the device, Zollhöfer et al. [34] create a high-quality personalized avatar that is designated for home use. The proposed algorithm combines robust non-rigid registration and fitting of a morphable face model to generate a high-quality reconstruction of the facial geometry and texture within seconds.

On [35], the authors describe a method to scan a human body using a single Kinect™ by aligning depth and colour scans provided by the device. They achieve a full 360° scan by moving the device freely around the object doing a full rotation in about 30 seconds. To process the data, they apply a 3D Super-Resolution (SR) algorithm followed by a loop-closing method specifically tailored for the Kinect™. Finally they execute non-rigid registration to correct residual errors of movements made. The result is a complete model with smooth surfaces and very good detailed structures (Fig. 8). By using the chosen motion device, the authors add that the main difficulties encountered are the low resolution and low accuracy of the depth sensor, plus its random noise.
In scene scanning and modelling, Henry et al. [36] built 3D dense maps of indoor environments aimed for the use in robotics. They used PrimeSense’s camera that is much equivalent to the one installed in Microsoft Kinect™ and employ a novel joint optimization algorithm and combine visual features plus shape-based alignment. Other uses of the device for 3D modelling have been conducted, but all more interesting is the Microsoft’s own research group KinectFusion [37]. By using one Kinect™ and with hand-held movement, it is possible to reconstruct a high-quality 3D model of the scene. The system captures the scene and for every viewpoint available it renders enhancements onto the model.

As with in [36-39], the use of disparity maps rendered by Kinect™ to introduce 3D information onto BCCT.core evaluation model can be very promising, its direct use is limited and poses adversities by its own resolution. Since the system would operate on disparity map images the measurements, and consequently the obtained ratios, are directly related to the pixels on which they were performed. Therefore the autonomous retrieval of independent breast features from disparity map images suffer from that lack of high resolution (HR) images. For that reason, there is a crucial need to work with HR images from the low resolution (LR) rendered by the device.
6. Super-Resolution

By representing a three-dimensional scene into every pixel of an image it is implicit that the higher the number of pixels a depth sensor can produce, the higher accuracy it will provide. By defining the use of the Kinect™ device the technology is a fixed asset, so coping with its limitations represents working with a set of LR images. Therefore to withstand the necessity to work on high resolution it is needed to transform the collected LR images from the device to a higher resolution set of images for further processing. The process which employs techniques to enhance the resolution of a set of images is called SR.

The SR methods can be roughly classified into multi-frames and single-frames variants, either applying algorithms in frequency or spatial domain. Frequency domain algorithms take advantage of redundant information present in the LR images by the shifting and aliasing properties of the Fourier transform, assuming that aliasing has occurred or attempt to extrapolate information to retrieve values within some intervals. Spatial domain algorithms usually employ regularization based approaches which enable a priori knowledge inclusion, non-uniform interpolation to have the advantage of low computational cost, Projection Onto Convex Sets (POCS) [37] usually designed for simplicity, Iterative Back Projection (IBP) [39, 40] for straightforward implementations, and Maximum A Posteriori (MAP) estimation.

For applicability in BCCT.core Super-Resolution processing runtime is desired to be at real-time and effective. Also, due to the nature of the rendered LR images, in gray scale, and the necessity to maintain the quality of edges, smooth areas and gradient consistency, SR applicable methods must render and preserve this features properly with minimal degradation. Also, particular attention is given to multi-frame methods since the Kinect™ can produce captures at video rate. Li et al. [41] proposed a multi-frame regularization-based method with new regularization items to yield better results in images with sharp edges and smooth flat regions. Although the performance of the proposed method led to “better results with noise suppression and detail preservation”, experiments were not conducted on depth maps. Moreover on range-enhanced oriented methods, new techniques have been proposed such as [42] reportedly registering enhances of spatial resolution up to 100 times, and [43] using both depth maps and colour images for the increase of resolution being computational efficient when compared to probabilistic approaches. On [42] (Fig. 9), the authors propose a method to enhance the resolution by iteratively refine the LR image using HR images as reference. They up-sample the LR input image to the high resolution camera image and process an iteratively refinement over the first image. The refinement module iteratively applies bilateral filtering to each slice of 3D volume of depth probability referred as cost volume. The HR image is obtained by selecting the depth hypothesis with the minimal cost followed by sub-pixel estimation. The approach presented in [43], uses an original interpolation technique exploiting side information from a
single colour camera image to increase resolution. The proposed method is performed by first pre-processing the colour image through a graph-based segmentation algorithm to identify main surfaces. Then a projection of points of the low resolution depth map is made on the segmented colour image to create a depth grid. The points within each grid are then the initial values of the low resolution depth map. The value of each pixel in the high resolution image is then estimated by interpolation of the grid samples belonging to same regions.

Fig. 9 - Experimental results from Yang et al. [42]
7. Automatic Feature Detection

In image processing, feature detection is the recognition of a region of interest that meets defined expectations or exhibits wanted characteristics (shape). General image features can be referred as edges, points delimitating two regions; corners, by applying edge detection with curvature characteristics; blobs, for the detection of regions, smoothed or with gradient-like characteristics; and ridges, usually one dimensional curve to represent symmetry on an image region. The ability of feature detection algorithms are often referred based on their efficiency and accuracy according to the desired output areas of perceptual significance. Feature detection methods usually use a priori knowledge either in the form of region markers or template matching. Regular feature extraction must be preceded with feature detection. The type of digital images used in this work makes essential the stellar detection of fiducial points, such the breast contour and the nipple complex.

For the extraction of 3D features regular 2D point detection needs to be performed in order to further retrieve volumetric information. By having depth maps that are taken from a fixed position, the 2D features presented in them are invariant to the scale, translation and rotation in the 2D planes. Some feature extraction algorithms are Scale-Invariant Feature Transform (SIFT) [44], Speeded Up Robust Features (SURF) [45], Gradient Location and Orientation Histogram (GLOSH) [46], the Local Energy based Shape Histogram (LESH) [47] and Spin Images [48]. These algorithms are capable of exploring one object’s unique features. However, the extraction of features using invariant-like methods such SIFT or Spin Images may not perform adequately on depth maps due to their point cloud development nature. In [49] the authors propose kernel descriptors for feature capture in 3D shape cues of objects. The nature of the objects itself pose a complete difference on the human body segmented areas. The methods proposed add important information to object identification and recognition, and show that complementary information over 3D point clouds can be gained with the use of depth maps. These types of feature extraction methods performance can be boosted by the inclusion of a priori classification or data sets in order to classify ordinal objects.

As previously stated, human body areas have many differences than ordinal objects thus its distinctive key points may become rather fuzzy so these methods can be effectively applied. By the application of 3D feature extraction methods we plan to retrieve volumetric features and further information that is not deduced from frontal 2D images used at the present moment.
8. Kinect specifications assessment

By defining the use of the Kinect™ device for 3D data acquisition, the knowledge of its operations conditions and technical restrictions is peremptory. By being capable of operating under any interior lighting conditions, and the fact that it is small and light equipment, makes it an easy to use apparatus. As previously stated the device renders depth maps with 640x480 pixels, but it is further needed to know its range accuracy and depth precision. An experimental procedure was conducted in order to retrieve the closest capture point and the depth curve according to the distance to the device.

Firstly, the closest point capture was registered was 485 millimetres (mm) measured by the near extreme point of the device towards the object. It was used a simple cubic form as the object to be detected and was iteratively placed in front of the device till a capture of the full frontal side of the object was available.

To verify the depth precision step accordingly to capture distance one cubic object was placed at a distance of 594mm, and a second identical object placed a couple centimetres further away. The depth values are then obtained through the de-normalization using Eq. 1.1, where “dm” is the input depth value and “dr” is the raw depth value previous to normalization performed by the Kinect™ drivers used. The registered values were 725 and 864, respectively. By this, at a distance of 594mm the minimum theoretical distance difference that the device is capable of capture is 4.27mm (Eq. 1.2).

\[
\frac{\sqrt[3]{dm}}{\sqrt{9216}} \times 2047 \equiv dr, \quad (1.1)
\]

\[
prec = \frac{594mm}{864 - 725} \approx 4.27mm, \quad (1.2)
\]

In order to retrieve the depth curve, one object was iteratively placed in front of the device at several distances spaced 100mm till the 1 meter mark. The registered depth curve can be seen in Fig. 10, where the green curve represents the values rendered by the device and collected through visual inspection. The blue curve is obtained by de-normalizing the input.
Through the visualization of Figure 8, we can deduce that an experimental error has occurred, either from observation or object misplacement. The fact that the method of registry employed was performed with multiple captures and object placement step was quite high when compared to the theoretical depth precision, leads to the necessity of the repetition of the experimental procedure. This new procedure shall use a large numbers of objects and the data registration should also be taken in only a single capture, so no external variables may influence the sensors performance.
9. **Work Plan**

In the pursuit of an enrichment and greater autonomy of the BCCT.core system, the achievement of the objectives proposed become a tremendous step forward in the use of 3D data onto the system. It is presented in this chapter the chronological framework of tasks to be performed. In Fig. 11 is represented the project’s schedule through a Gantt chart.

Scheduled to have 7 phases, this project starts with a literature review on SR and Automatic Feature Detection methods (phase 1). The second phase is responsible of analyzing the captured data and to enhance it using SR methods, so images are suitable to be used. The phase 4 uses the higher resolution images obtained from the previous step so an automatically feature detection can be performed. After phase 2 and 4, respectively phases 3 and 5, is made an evaluation on the previously applied techniques in order to verify its results. The verification allows to conclude which methods gathered the best results as well to fully comprehend the extension of improvements made.

After all improvements a final assessment of the, then, achieved model is necessary (phase 5). Refinements are performed after the model evaluation to obtain maximum efficiency, which represents the phase 6. The final phase (phase 7) corresponds to writing the dissertation and the completion of the project.

During the project, the computing activities will consist in image processing and its applied algorithmic procedures. For that purpose it will be used Mathworks®’s Matlab® development environment.
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Reference List


Reference List

Kinect specifications assessment


