Abstract
The goal of this study, is to use Mask Technique and Center Detection for developmental dysplasia of the Hip (DDH) diagnosis [7] which aims at calculating center and diameter of Head of Femur to diagnose some of the effects of Developmental Dysplasia of the Hip (DDH) on the hip joint. This study uses the Mask Technique and Center detection to complete the calculation of the acetabular angle and the distance of the head of femur from acetabulum. These two new criteria give the doctor very valuable information in the diagnosis of DDH and its degree.

An algorithm is designed to do the following steps:
1. Exploring the details of the X-Ray and cutting out the necessary parts (acetabular bone and head of femur) for the desired side (right or left) instead of using the complete image.
2. Enhance the cropped parts by using Contrast linear stretching, Median filter and Canny edge detection.
3. Search for the center of the head of femur and calculate its diameter.
4. Measure the angle of acetabular bone and measure the distance from head of femur to acetabular bone.

At last the features are extracted (Center of head of femur, Intensity value of the center, Diameter of head of femur, angle of acetabulum and distance from head of femur to the acetabulum, place in acetabulum bone). We applied this system in computer using Matlab 7.0 programming Langue.

Introduction
Congenital Dislocation of the Hip (CDH) is the old name and we depend here on the new name Developmental Dysplasia of the Hip (DDH) [3]. This is a common abnormality that affects hip joints in newborns leading to various degrees of displacement of femoral head from its socket.

The diagnosis of DDH using conventional x-ray films represents a challenge to the clinician especially when the amount of displacement of the femoral head from its socket (the acetabulum) is borderline.

Several parameters were, for this reason, established to assist in diagnosis. Most of these parameters depend on measurement of distances and angles or even naked eye appreciation with the resultant bias due to inter-observer variations [2], Figure (1).

There are two important features that are useful for diagnosis and for the purpose of classification and grouping of hip abnormalities in DDH; [3]
1. Lateral displacement of femoral head.
2. Acetabular angle of inclination.

In Matlab version(7), this instruction could be used to do this job:
Bw = imcrop (image)
-  (image) is two dimensional array of the grey level image Congenital Dislocation of the Hip (DDH), as previously shown in Figure (2).
-  (BW) is two dimensional array of grey level image that contains head of femur and socket (acetabulum), as shown in Figure(3).

Figure (2): The original image for bilateral DDH.

Figure (3): The acetabulum part for the right side.
3. Contrast linear stretching.
The job of this step of segmentation algorithms is to expand the narrow range of brightness values of an input image over a wider range of gray values then results in an output image that accentuates the contrast among the features of interest.
The formula that is used in this work of linear stretch is [5]:

\[ DN_{cs} = \frac{DN - MIN}{MAX - MIN} \times 255 \]

Where:
DN: is the original grey level image
MIN: is minimize the value of grey level in the image
MAX: is maximize the value of grey level in the image
DN_{cs}: is the result image of linear stretch contrast as shown in Figure (4)

4. Smoothing.
Median filter is the technique that is used in this study to smooth image crop. Median filter is a nonlinear spatial based on the median brightness value of each input group of pixels [1]. In a set of ordered values, the median is the central values. The median of a set of number of two dimensional array is the value which is (50%) above and (50%) below so if a pixel is accidentally changed to an extreme value, it will be eliminated from the image and replaced by a reasonable value in the neighborhood as shown in Figure (5).
Median filter is one of the best edge preserving and smoothing filters. Its primary use is removing impulse noise spike from an image. Impulse noise spike appears as bright to dark pixels randomly distributed throughout the image. Because spikes are significantly brighter or darker than their neighboring pixels, they generally end up at the top of bottom of brightness ranking for a group of input pixels and so it is generally avoided and eliminate in the output image [1].

<table>
<thead>
<tr>
<th>Input image</th>
<th>Median filter</th>
<th>Output image</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 36 20</td>
<td>30 36 20</td>
<td></td>
</tr>
<tr>
<td>8 60 17</td>
<td>8 25 17</td>
<td></td>
</tr>
<tr>
<td>19 25 28</td>
<td>19 25 28</td>
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Figure (5): Median filter Technique.

Median filter reduces the burying of edge [4]. In this study, the median filter has been programmed to accept the square size of window while the executive time of program from user size of window can be (3×3) or (5×5), depending on the image of the different size of median filter that gives the system more accuracy to detect the edge of an abnormal region of image, as shown in Figure (6).

Figure (6): Median filter for the acetabulum part for the right side.

5. Crop head of femur.
This step is completely like step2, but the result is sent to Head of Femur Detection algorithm (we explain it later in page 7) to calculate center and diameter of Head of Femur, as shown in Figure (7).

Figure (7): The cropped head of femur.

6. Canny edge detection.
You can use the edge function to detect edges, which are those places in an image that correspond to object boundaries. To find edges, this function looks for places in the image where the intensity changes rapidly, using one of these two criteria:
- Places where the first derivative of the intensity is larger in magnitude than some threshold
- Places where the second derivative of the intensity has a zero crossing
Edge provides a number of derivative estimators, each of which implements one of the definitions above. For some of these estimators, you can specify whether the operation should be sensitive to horizontal edges, vertical edges, or both. edge returns a binary image containing 1's where edges are found and 0's elsewhere.
The most powerful edge-detection method that edge provides is the Canny method. The Canny method differs from the other edge-detection methods in that it uses two different thresholds (to detect strong and weak edges), and includes the weak edges in the output only if they are connected to strong edges. This method is therefore less likely than the others to be fooled by noise, and more likely to detect true weak edges [6]. Show Figure (8)
The result of this algorithm DDH segmentation is the head of femur and socket (acetabulum), without any background.
The X-Ray region taken for DDH is too large, so we capture the head of femur in a separate image. The head of femur is almost like a circle, therefore novel techniques are proposed using mask, profile and combination between them for detection of the center of the head of femur. These techniques give high accuracy and reduce the execution time required to detect the head of femur.

Basically, the captured image has an undesirable space. This unadvisable space could be reduced by segmenting the head of femur image into segments, Figure (9) (Note, we try another size of mask like (32x32pixel) and (16x16pixel) but we found mask (8x8pixel) has the better result).

After segmentation to reduce search space, the convolution process is applied using a mask (2x2) with ones coefficients. By this way we find the center [7].

**Head of Femur Detection Using Mask**

The profile is a tool of an image processing technique. The profile of an image region is a projection of compact representation in the spatial pixel content distribution and has been successfully employed in this work. It is the set of intensity values taken from regularly spaced points along a line segment or multi-line path in an image. It could be applied for horizontal or vertical direction [7] [8].

A novel application is proposed for the technique of diameter detection by profile. The head of femur center is calculated by finding the maximum occurrence of an intensity value in the rows and columns. The center lies on white region; therefore the highest intensity value has the maximum occurrence in the profile. The column index of the maximum occurrence represents the X coordinate of the head of femur center. The row index of the maximum occurrence represents the Y coordinate of the head of femur center. Figure (10) shows the center and the circle that we calculate diameter for it later.

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**Calculate the degree of DDH**

The radius of the head of femur RAD as shown in the Figure (3) above, is calculated as the average of two calculated radii R1 and R2. The radius R1 is calculated from the minimum values of column profile compared with X coordinate of the center, denoted as COLmin. Then the radius R1 is calculated according to the following equation:

\[ R1 = \text{abs}(X - \text{COL}_{\text{min}}) \]

The radius R2 is calculated from the minimum values of row profile compared with Y coordinate of the center, denoted as ROWmin. Then the radius R2 is calculated according to the following equation:

\[ R2 = \text{abs}(Y - \text{ROW}_{\text{min}}) \]

Now, we have two radius values one for column R1 and another for row R2, The Diameter DIAM of the head of femur is calculated according to the following equation:

\[ \text{DIAM} = R1 + R2 \]

While, The radius RAD of the head of femur is calculated according to the following equation:

\[ \text{RAD} = (R1 + R2)/2 \]

Note, the diameter and the radius are in pixel, so we divide them on the resolution of images to obtain them in centimeter, but this size does not represent the real size of head of femur because it depends on how we picture the image (perspective effect), so we compute the percentage of diameter size between diseased and normal sides which is the most important feature for diagnosis.

\[ M1= \frac{y3 - y2}{\Delta y} \quad M2= \frac{x3 - x2}{\Delta x} \]

\[ M1= \tan \Theta_1 \quad M2= \tan \Theta_2 \]
At last we draw a line started from the head of femur (from center minus half diameter) to the acetabulum bone, which represent the distance that the head of femur move away from his place in the acetabulum bone. Note that we measure this distance in millimeters. Figure (1) shows the two lines, angle of acetabulum bone, center of head of femur, diameter of head of femur and distance from head of femur to acetabulum bone.

Figure (1): Angle of acetabulum bone and distance from circle of head of femur to acetabulum bone.
Figure (12): Flow chart of DDH Segmentation Algorithm, Head of Femur Detection algorithm and Calculate the degree of DDH.
Result

1. Image for bilateral DDH, Figure (13).

Right side result:
a. Canny = 1
b. Center (X,Y) = (51,118)
c. Center Intensity = 97
d. Diameter = 2.7556mm
e. Angle = 32.942 °

Left side result:
a. Canny = 1
b. Center (X,Y) = (160,141)
c. Center Intensity = 104
d. Diameter = 2.7653mm
e. Angle = 37.7939 °
f. Distance = 24.3724mm

2. Image for left DDH, Figure (14).

Right side result:
a. Canny = 1
b. Center (X,Y) = (50,95)
c. Center Intensity = 151
d. Diameter = 3.9206mm
e. Angle = 28.8557 °
f. Distance = 5.4487mm

Left side result:
a. Canny = 1
b. Center (X,Y) = (172,117)
c. Center Intensity = 145
d. Diameter = 1.5760mm
e. Angle = 46.1691 °
f. Distance = 27.7895mm

Figure (13): (a): Image for bilateral DDH. (b): Angle and distance for the right side. (c): Angle and distance for the left side.
3. Image for left DDH, Figure (15).

**Right side result:**
- a. Canny = 4
- b. Center (X,Y) = (136,171)
- c. Center Intensity = 107
- d. Diameter = 3.8543mm
- e. Angle = 34.7432°
- f. Distance = 4.0706mm

**Left side result:**
- a. Canny = 2
- b. Center (X,Y) = (208,52)
- c. Center Intensity = 72
- d. Diameter = 1.6945mm
- e. Angle = 37.5065°
- f. Distance = 31.2583mm

Figure (14): (a): Image for left DDH. (b): Angle and distance for the right side. (c): Angle and distance for the left side.
4. Image for left DDH, Figure (16).

Right side result:

a. Canny = 2
b. Center (X, Y) = (135, 204)
c. Center Intensity = 82
d. Diameter = 4.6739 mm
e. Angle = 30.5560°
f. Distance = 23.7709 mm

Left side result:

a. Canny = 3
b. Center (X, Y) = (428, 173)
c. Center Intensity = 53
d. Diameter = 1.8114 mm
e. Angle = 40.3836°
f. Distance = 104.9368

Figure (15): (a): Image for left DDH. (b): Angle and distance for the right side. (c): Angle and distance for the left side.
5. Image for Normal case, Figure (17).

Right side result:
- a. Canny = 3
- b. Center (X,Y) = (122,179)
- c. Center Intensity = 108
- d. Diameter = 2.8617mm
- e. Angle = 29.1343°
- f. Distance = 10.5646mm

Left side result:
- a. Canny = 3
- b. Center (X,Y) = (157,142)
- c. Center Intensity = 113
- d. Diameter = 2.5084
- e. Angle = 27.5820°
- f. Distance = 13.2109mm

Figure (16): (a): Image for left DDH. (b): Angle and distance for the right side. (c): Angle and distance for the left side.
Conclusions

1. We used Mask Technique to capture the desired area. This technique gives high accuracy and reduces the execution time required to detect these features, and can be used to detect other problems.

2. Diagnosis is done in two phases:
   - Search on the center of the head of femur and calculate its diameter.
   - Measure the angle of acetabulum bone and measure the distance from head of femur to acetabulum bone.

3. Finds new features Diameter, center and angle detection which can be used for any problem which has a shape like circle and triangle.

4. Do not need this system for large memory, but a small memory to store the picture before diagnosis and another to store the small cropped parts.

5. This diagnosis system is very simple and do not need any steps or rotations to learn like artificial techniques, and this helps to reduce the execution time required to detect these features.

6. This diagnosis system helps to diagnose one of the DDH effects on the upper end of the femur bone for child which help the doctor to observe one of the affections of DDH, and to detect the angle of acetabulum which help the doctor to diagnoses the degree of DDH.

7. In the future this system needs a library with normal measurements to compare with it, like the normal size of head of femur and angle of acetabulum for each child age.

Figure (17): (a): Image for normal case. (b): Angle and distance for the right side. (c): Angle and distance for the left side.
References
