Experimental investigation for low pass filter to image processing

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Abstract

The experimental works have been designed and implemented for testing the filters used in image processing .The coherent low pass filter using pinhole apertures of different sizes. two types of transparencies were prepared by computer (as objects), a text printed on black background and a text printed on thermal paper. The computer simulation on matlab were developed in this work. The coherent low pass filter . The results show a dramatic agreement between the experimental and theoretical work. The size of the effective pinhole on the filtered images were (0.25-0.5 mm). The best size was 0.5mm sizes.

Keywords: low pass filter , pinhole apertures, image processing,

التقصي التجريبي لمرشح المرور الضئيل المتشاكه لمعالجة الصور

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الخـــــلاصـــة :

تم تصميم وتنفيذ تجربة لعملية فحص عمل الفلاتر المستخدمة في المعالجة الصورية . وهو مرشح المرور الضئيل المتشاكه باستخدام الفتحة النقطية باعتبارها مرشح المرور الضئيل . تم تحضير نوعين من الشفافيات بالحاسوب الاول طباعة الحروف على خلفية معتمة (سوداء) لتمثيل الشيء والثانية طباعة فتحة دائرية مختلفة الاحجام على ورق شفاف حراري لعمل فلتر نقطي .

كما تم تطوير برنامج على الحاسوب بلغة الماتلاب لمحاكاة التجربة العملية، وهي مرشح المرور الضئيل المتشاكه. اظهرت النتائج وجود تقارب كبير بين النتائج العملية والنظرية وكان لحجم الفتحة النقطية تاثير في جودة الصورة المستخرجة . وكان حجم الفتحة الدائرية فعال على جودة الصورة المستخرجة ، أذ كان افضل صورة تم الحصول عليها من خلال الفتحة الدائرية عندما كان عرض الفلتر 0.5 ملم.

الكلمات المفتاحية : مرشح المرور الضئيل المتشاكه ، الفتحة النقطية ، المعالجة الصورية

1-Introduction:

The digital image processing is used in many domains today. In image enhancement, for example, a variety of methods now exists for removing image degradations and emphasizing important image information, and in computer graphics. Digital images can be generated, modified, and combined for a wide variety of visual effects. In data compression, images may be efficiently stored and transmitted if translated into a compact digital code. In machine vision, automatic inspection systems and robots can make simple decisions based on the digitized input from a television camera [1].

The spatial filtering technique consists in three successive operations Fourier transformation (FT) of the image modification of its spectrum by the spatial filter, and inverse Fourier transformation (IFT)[2].

The 4F optical system with spatial filtering and collimating processes uses two identical lenses in order to get clear phase and amplitude information [3].
In this research we introduce experimental work with low pass filter.

2-Two-Lens Image System (4F System).

Is traditionally attractive for image processing. It consists of two lenses of focal lengths f_1 and f_2 such that f_1 =f_2= f.

, a transparency on the Fourier plane can be inserted. The Fourier plane transparency is commonly called a spatial filter $s_f(x,y)$.The Fourier plane of the two lens system is called the pupil function p_f and the spatial filter is also called the pupil function of the system. The transform of the system is given [4,6] :

$$\psi p_i(x,y,f) = \frac{jk_0}{2\pi f}\exp[-jk_0(d_0+f)]\exp\left[-j\frac{k_0}{2f}\left(1-\frac{d_0}{f}\right)(x^2+y^2)\right] \times T(k_x,k_y)\Big|_{\substack{k_x=\frac{k_0x}{f}\\ k_y=\frac{k_0y}{f}}}$$

The Fourier transform of the input transparency appears on the common focal plane (or the Fourier plane). In order to perform Fourier plane processing on the input transparency

When a transparency $\mathrm{t}(x,y)$. is placed on the front focal plane of lens L_1, as shown in Figure (1), the field distribution on the common focal plane is given by ignoring some unessential constants, $T(k_0x/\ f_1,k_0y/f_1)$, where we have assumed that the transparency is illuminated by a plane wave. Then, this field distribution is modified by the spatial filter [5,7,8].

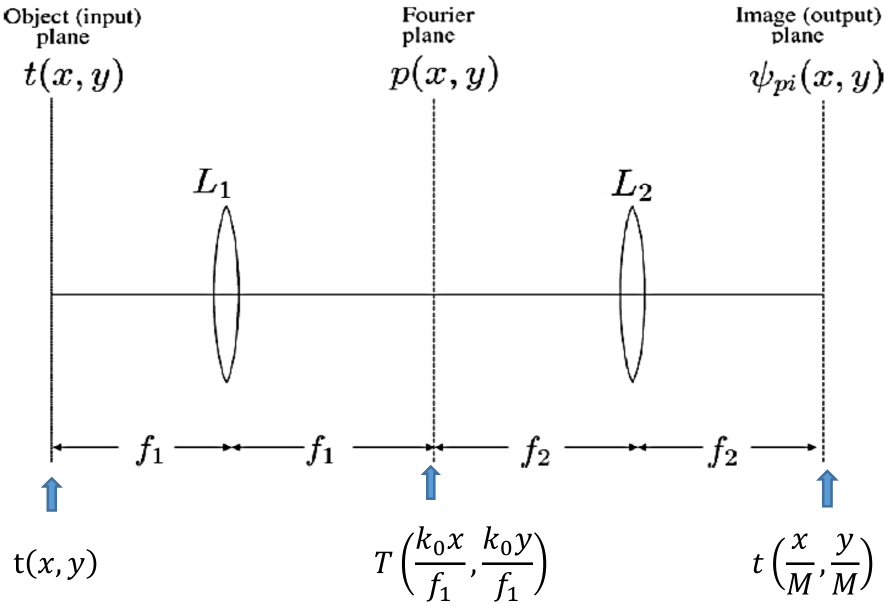


Figure (1): Standard two-lens imaging processing system.

$$where, \qquad M = -\frac{f_2}{f_1} \quad \text{is the magnification factor}$$

3-Coherent low pass filter

In describing the two stage process of coherent optical image formation, we have seen that the quality of an image is determined by the information reaching it from the object. Specifically, the quality depends on the faithfulness with which its constituent spatial frequency spectrum is a replica of that of the object. We have also seen that the spatial frequency spectrum is accessible in the diffraction plane; one in which image quality deteriorates when high frequencies are removed by simply placing an aperture in the diffraction plane to prevent frequencies above a certain value from contributing to the formation of the image a low-pass filter. That is a very simple example of coherent spatial (frequency) filtering [9]. As shown in Figure(4), coherent spatial filtering is used in a two-lens system, in the spatial domain and its corresponding radius, kr_0 [radian/cm].

4-Experiment

In this Experiment, pinhole filter was implemented. The experiment setup was arranged as shown in Figure (2). 4f System with two lenses.

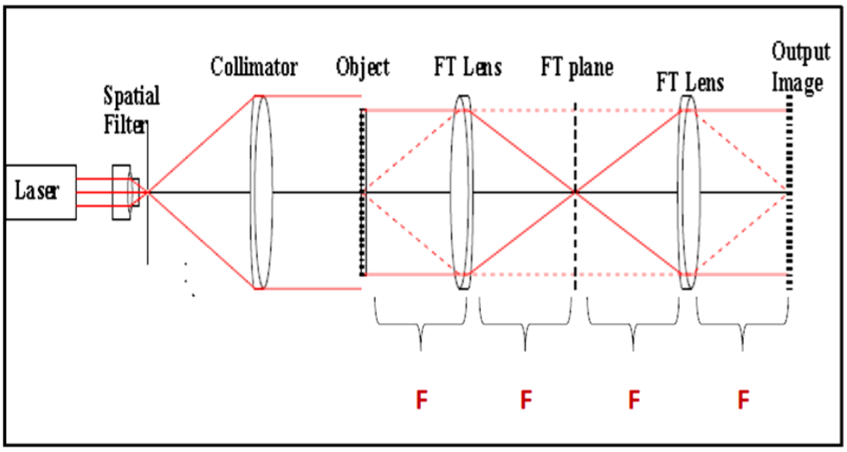


Figure (2): 4F Optical System

(A) (B)

Figure (3): A) transparent with black background. B) Thermal paper

Two types of objects were used.

1- Different kinds of objects were printed on transparent with black background.
2- Object's images were printed on thermal paper. As shown in figure (3).

The Laser beams were directed toward the beam expanding in order to obtain plane wave front parallel to the workbench with big radius. This wave was ready to incident on the object after reflection across the plane mirrors. The resulted image of the filters and the object were exposed to the CCD Camera at distance equal to the focal length of the lenses was interfaced with the Laptop. The images of different object were taken without filter. Then the filter was fixed on a 3-D transmission optical device. This devise was used to pass the Laser beam on the plane of the filter. Thus the image would be formed behind the lens with different sizes of pinholes. It should be mentioned that during this experiment work, the laser beam should be parallel, and measurement of its diameter was performed.

Fig(5) show the schematic diagram of the experimental setup used in this experiment.

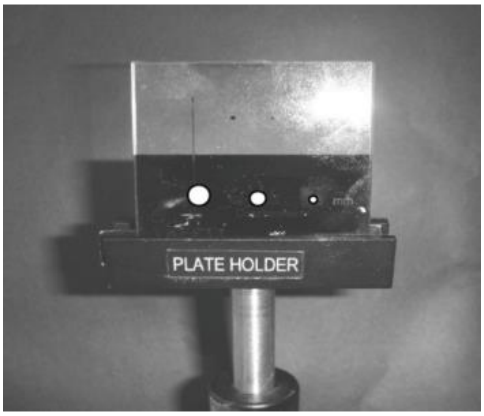
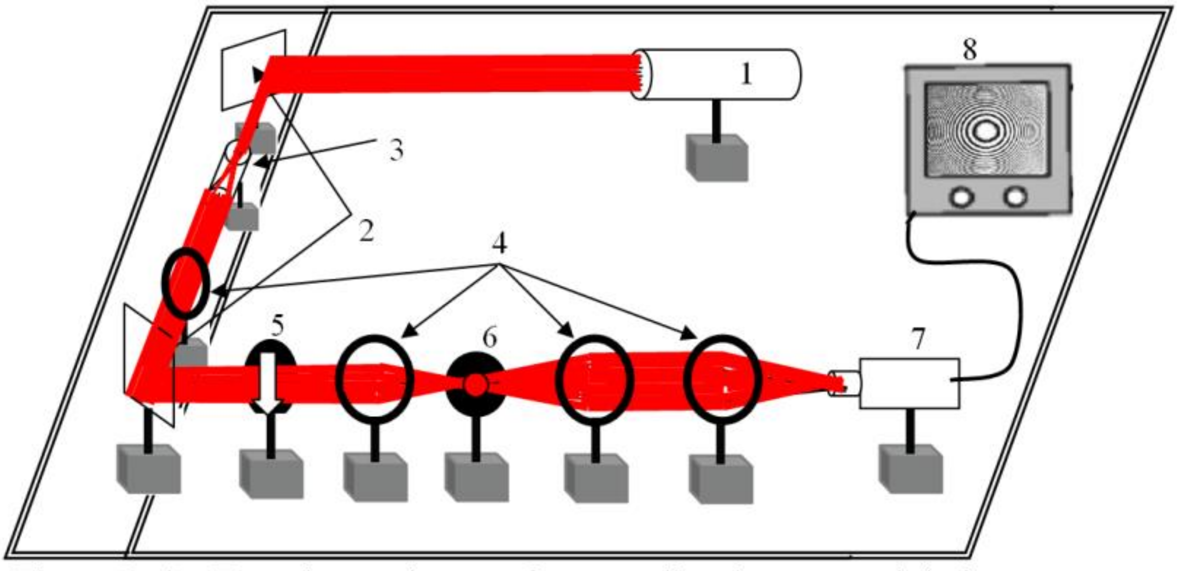


Figure (4) :Pinhole filter (Lowpass filter).



Figure(5): Experimental setup for recording low pass pinhole aperture.

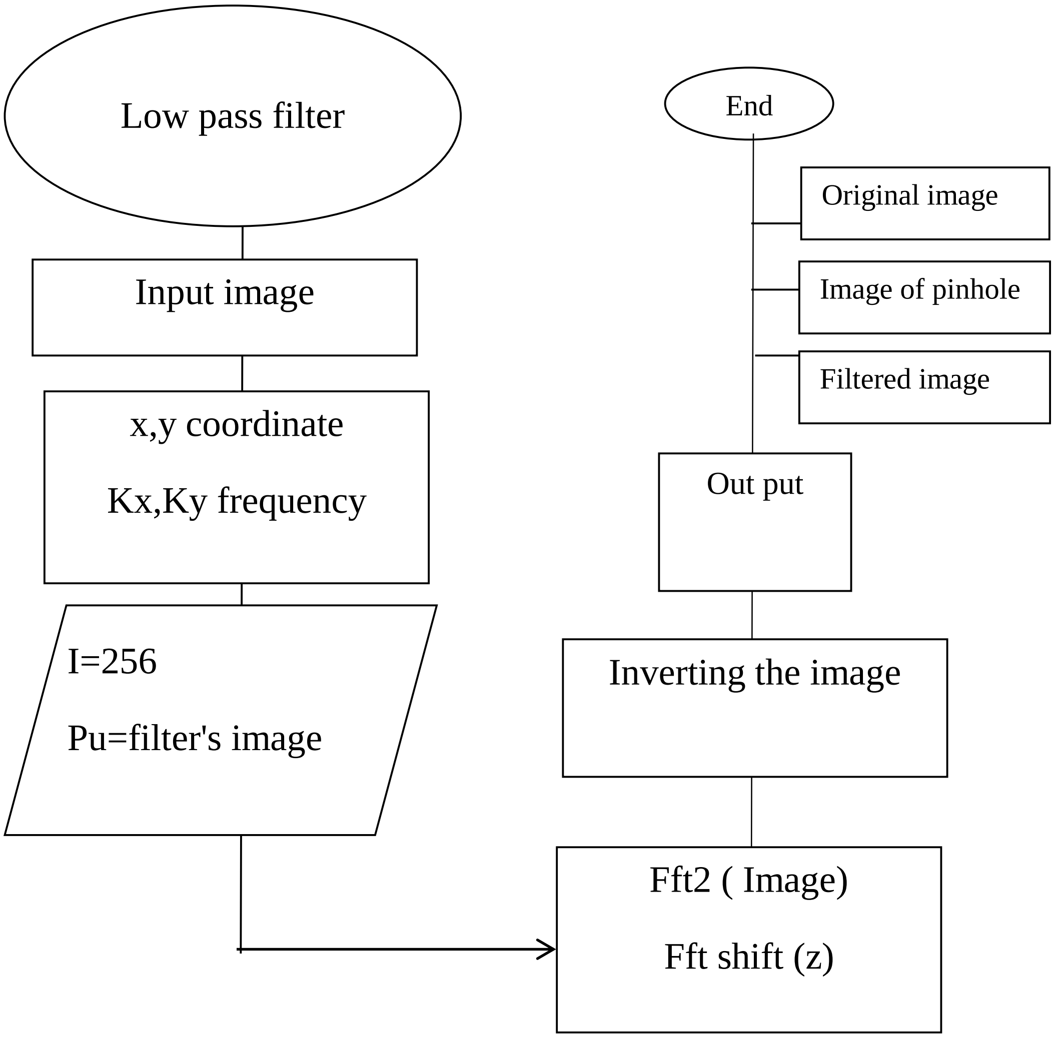
1- laser; 2-mirror ; 3-beam divergence ; 4-lens; 5-object ;6-pinhole filter 7-CCD camera; 8 -computer .

Computer Simulation

The experimental results were supported by computer simulation in Matlab. The fft2 and ifft2 were used . The program was developed in this work.

a) Coherent Low pass filter

The flowchart contains the main steps of algorithm



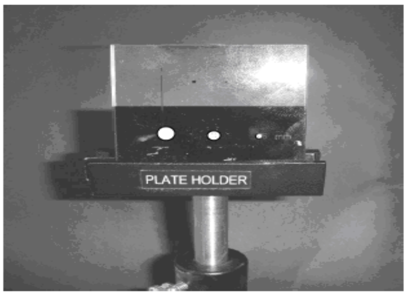
5-Measurements

The experimental results of low pass and band pass filters are illuminated on CCD camera which is interfaced with PC (Laptop). The objective transparencies (abc and ABC) were printed on papers and entered as inputs to the experiments. Two sizes of pinholes (0.25mm and 0.5mm) were implemented in the first experiment and used as coherent low pass filter. In the first experiment, an optical workbench was implemented. Two circular pinholes shown in fig. (6-a) were used as lower pass filters. Two texts abc and ABC were entered as transparencies. The results are shown in Fig. (6-a) . The blurred image is without filter and the output image with

The text abc was entered into the first experiment. Fig.(6-a) shows the blurred images obtain using 0.25mm, circular aperture as a low pass filter.

This defect can be attributed to the selected size of the filter, the aberration of the lenses, and the exact position of the confocal plane. However, the results of computer simulation in Fig.(6-b) show a dramatic agreement between the experimental and theoretical work.

Pinhole, radius 0.25mm



Fourier filter

pinhole, radius 0.25mm with out Filtered

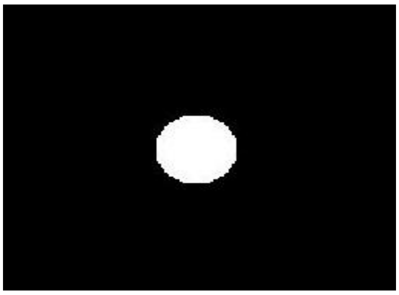
Intensity & image plane

pinhole, radius 0.25mm with Filtered

Intensity & image plane

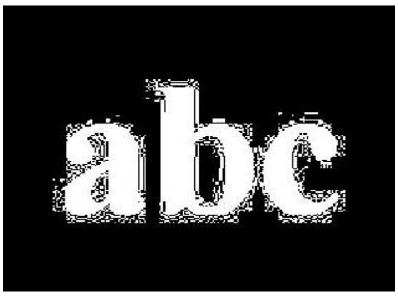
Fig.(6-a): The experimental results of Low–pass filtering image with radius 0.25 and after simulation by computer by using matlab .

Pinhole, radius 0.25mm



Fourier filter

pinhole, radius 0.25mm without Filtered



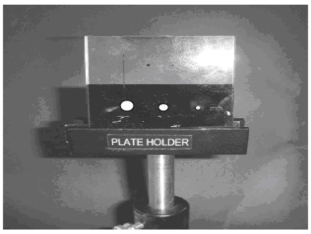
Intensity & image plane

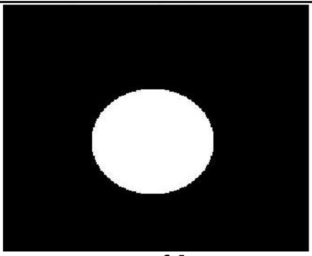
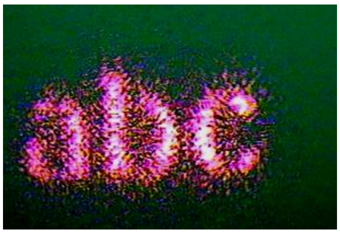
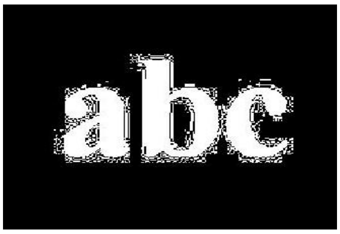
pinhole, radius 0.25mm with Filtered

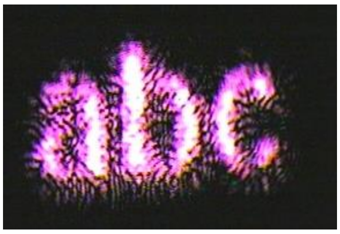
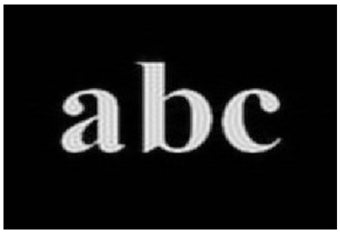
Intensity & image plane

Fig.(6-b): The Simulation by computer results of Low–pass filtering image with radius 0.25mm

The size of circular aperture was (0.25mm). It can be seen from these two figures, that, there appear a dramatic agreement between theoretical and experimental work. Better images were obtained by using another pinhole of size (0.5mm). These results are shown in fig (7-a and b) .

<table>
<tr><td colspan="2">Pinhole, radius 0.5mm</td></tr>
<tr><td>

Fourier filter</td><td>
Fourier filter</td></tr>
<tr><td colspan="2">pinhole, radius 0.5mm without Filtered</td></tr>
<tr><td>
Intensity & image plane</td><td>

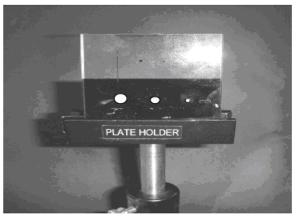
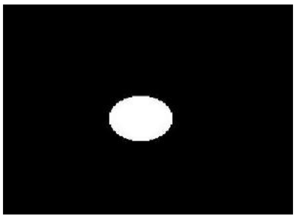
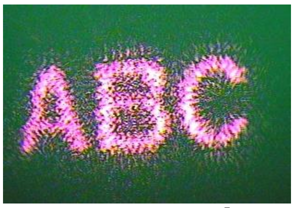
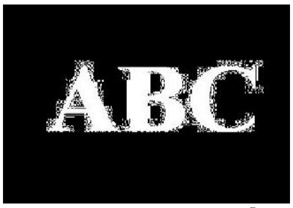
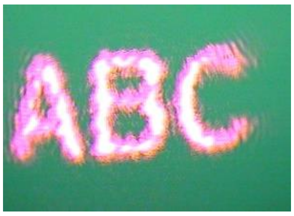
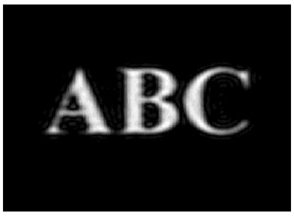
Intensity & image plane</td></tr>
<tr><td colspan="2">pinhole, radius 0.5mm with Filtered</td></tr>
<tr><td>
Intensity & image plane</td><td>

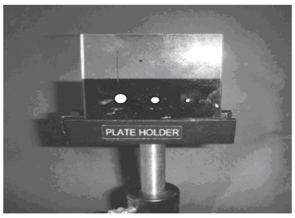
Intensity & image plane</td></tr>
<tr><td>Fig.(7-a) The experimental results of Low–pass filtering image with radius 0.5</td><td>Fig.(7-b) The simulation by computer results of Low–pass filtering image with radius 0.5mm</td></tr>
</table>

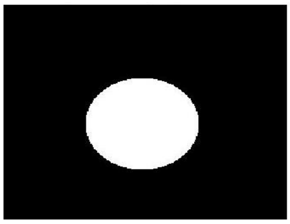
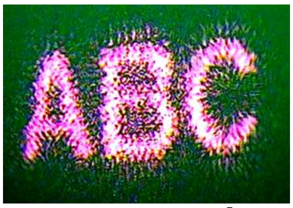
Figures (7-a, and b) show better results obtained by selecting (0.5mm) of the pinhole, because the large of the filter led to increase the amount of light entering through it, as well as the large of filter impacted on the diffraction resulting from the edges of inner filter and thus the diffraction effect of a few and that is what led to the enhancement in the image used.

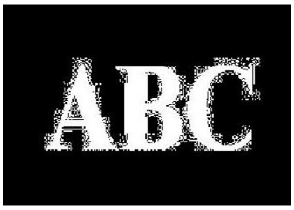
For more precise experimental work, the coherent low pass filter using circular aperture (0.25 mm and 0.5mm).

The results are shown in figure (8-a, and b) for the object (ABC).

Pinhole, radius 0.25mm	
 Fourier filter	 Fourier filter
pinhole, radius 0.25mm without Filtered	
 Intensity & image plane	 Intensity & image plane
pinhole, radius 0.25mm with Filtered	
 Intensity & image plane	 Intensity & image plane
Fig.(8-a) The experimental results of Low pass filtering image with radius 0.25mm	Fig.(8-b) The simulation by computer results of Low pass filtering image with radius 0.25mm

<table>
<tr><td colspan="2">Pinhole, radius 0.5mm</td></tr>
<tr><td>

Fourier filter</td><td>
Fourier filter</td></tr>
<tr><td colspan="2">pinhole, radius 0.5mm without Filtered</td></tr>
<tr><td>

Intensity & image plane</td><td>

Intensity & image plane</td></tr>
<tr><td colspan="2">pinhole, radius 0.5mm with Filtered</td></tr>
<tr><td>

Intensity & image plane</td><td>

Intensity & image plane</td></tr>
<tr><td>Fig.(9-a) Show the experimental Low–pass filtering image with radius 0.5</td><td>Fig.(9-b) Show the simulation by computer Low–pass filtering image with radius 0.5mm.</td></tr>
</table>

Fig.(9-a, and b) shows the comparison between experimental and theoretical results using a pinhole of size 0.5 mm nmnnjnwhere we obtain brighter image than before because of the same reasons previously mentioned.

5- Conclusions

In optical image processing the experimental work has been performed. Low pass filter using pinhole with different sizes beside this experimental a computer

1-The size of pinhole was on effective factor on the resolution of the obtained image, i.e. increasing the size of the pinhole within a limited range will enhance the resolution of the filtered image.

simulation was developed. A comparison between experimental and simulation were made. The results showed a close agreement between the experiment and simulation. The following concluding remark can be drawn:

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