

Laser Tweezers For Medical Applications

Posted on October 25, 2019

Trapping RBCs in Living Animals Via Optical Tweezers

The article discusses the manipulation of red blood cells *in vivo* using infrared optical tweezers. Optical tweezers confine and tamper with biological cells in living animals through a laser that penetrates through biological tissues. The study optically obtained and changed flowing red blood cells in the blood capillaries of living animals.

Keywords- Laser tweezers, optical tweezers, trapping

Although no research examines how cells are distorted and imprisoned in living animals, the researchers believe that they can use “atomic force microscopy and biomembrane analysis to capture and alter magnetic beads attached to the tethering surface by molecule chain” [1, pp. 1]. They support their arguments using the ear of a mouse to identify the flow of blood in the capillaries. With the optical tweezers, the researchers induced artificial clots of red blood cells in capillaries. Investigations of live animals raise major problems in heat-induced cell damage [1, pp. 2]. For this reason, it was difficult to detect any thermal damage to the trapped cells 40µm deep in the experiments with a 168mW trapping laser power.

The researchers supported these observations by claiming that the trapped cells conducted heat well because of the water content and the fact that they were immersed in the flowing blood. Another explanation was that the blood flow *in vivo* helped in the reduction of any likely heat accumulation, hence preventing any detection of visible thermal damage through laser light absorption into the trapped cells [1, pp. 2]. However, optical tweezers can catch microscopic particles *in vitro* or organelles in cells using non-contact force through the transfer of photon linear energy. [1, pp. 2]. They can also be applied as a quantitative instrument in biophysical research to measure a molecule binding force, study the kinetochore-microtubule relationship, and quantify intercellular relations.

- Growth Pattern of Yeast Cells Studied Under Optical Tweezers

The journal article explores the growth pattern of yeast cells in the human body. The researchers start by explaining the origins of optical tweezers before studying the pattern of growth in yeast cells. Ashkin observed he could use a laser beam to manipulate particular objects and build a three-dimensional tool called the laser tweezers.

Keywords- Laser tweezers, optical tweezers, medical applications, trapping.

In 1986, Arthur Ashkin created a powerful instrument to modify microscopic particles without using any laser focus beam [2, pp. 198-201]. The tool allowed the entrapment of a microscopic element through a high arithmetic aperture microscopic objective. The researchers selected *Saccharomyces bayanus* grown using common cultivation on potato dextrose broth (PDB) for this study [2, pp. 200]. They then used the 1064 nm fiber laser to set time-shared several optical traps to attain the preferred pattern of different trapping beams beneath a Nikkon Ti-U reversed microscope [2, pp. 200].

The researchers then placed the sample in optical tweezers to explore the growth arrangement of yeast cells [2, pp. 200]. In the end, the study concluded that yeast emergence happened in a linear shape pattern because of localized heating effects caused by absorption at a focal point, hence causing the induced direction of yeast development [2, pp. 200]. The experimentation data was obtained using the Richards function. The researchers ended by suggesting that the food rate makes major contributions to the growth rate of yeast cells.

In conclusion, the introduction of laser or optical tweezers by Arthur Ashkin allowed easier trapping and manipulation of substances under study. Scientists and researchers used the tool to understand scientific or chemical matters of microscopic objects. Laser tweezers operate in a unique manner by focusing a laser beam on the specimen being studied. Results from the summarized articles indicate that optical tweezers provide results depending on the organisms introduced for research.

The essay contains a discussion of the laser tweezers and the procedure of how the laser tweezers are being experimented in the laboratories. The study also gives the details of how the beam reflects, and the table is used to provide information on the measurement of the energy dissipation of the beam at the time of passing.

Introduction:

The device that was used for catching the neutrally charged optic forces is done by Laser tweezers, which include the radiation pressure and concentrated laser beam tightly. This equipment has a lot of applications in the field of medical science, study projects and much more. The Nano tracker was used in the equipment for light particle objects, which were used for medical applications and had the most advantages.

Laser Tweezers Experimental Procedure:

The laser tweezers are used in the research where it acts as an excellent inducer of the experiments in the laboratories. This has an advancement in the design where it is now possible to power lasers at a different wavelength at a cheaper cost as compared with before. It is used to measure the microscopic energy that was exerted by cellular transactions in the area of biophysics. The availability of massive transfer ably available coated with protein polyester beads allows the research people to get communication and information through the cell, and its precision in the external environment is

very flexible.

It was an experimental procedure the usage of the apparatus was to familiarize myself with the fundamental theory and functioning of laser trapping. This experiment apparatus is costlier and potentially dangerous. More necessary actions are to be taken and also care while working with the equipment. Even when the experimental set up was in the off condition, there are caution actions to be followed to avoid minor problems. The alignment of the optical path will be changed even to the little upset of the way of the laser beams. It also requires a great effort, and also it consumes a lot of time as well. Adding to the suffering of the laser misalignment, they will be traveling at a power of 30 mW and are carried in the form of 633 nm photons, which readily absorb the retina and it affects which cause many problems to the eye. To avoid the same as mentioned above one must ensure their safety by wearing a safety glass that is goggles. We must take care of the apparatus if a slight rest is taken, and if any small problem occurs due to negligence causes many issues both from the human perspective and also for the device, resulting in the loss of money, as already mentioned, the apparatus will be costly.

Coming to the working part, the helium-neon gas was the mainly used. Firstly, the mirrors are placed for the reflection and also for the focusing of the beams at the correct angle. Adding to that, the mirror also steers the laser beam to diverge at specific heights. After passing through the mirror, it passes through the lens to get magnified, and the beam strikes at the third mirror, which is used for giving the beam the optimal radius of curvature. Later on, the beam will pass through another mirror, that is, the fourth mirror and then passes through the aluminum adapter, which will be at the top of the microscope. The adapter will have reflectors that show many different colors reflectors. When the red-colored laser passes through the dichroic reflectors, it reflects the bottom and also to the backside of the microscope. The particle that was placed in the path of the laser beam will create an impact on the mirror, which can be focused through the mirror and can be used for further reference.

The experiment was done by calculating the energy that was dissipated when the laser beam passed through the mirror and also when it struck the screen. Also, the variation of the laser beam path was detected to show the correct value for the results obtained by using the equipment. By using this, a great foundation like the working of wrist watch can be formed.

Introduction:

In this experiment, the separation of the light, that is, the polarization of the light, was obtained by having a vice-versa directional, which was directly proportional to the angle of orbital angular momentum. The wavelength was also calculated during the project in between the process as the primary source for the final result of the project.

Optics Rotation Project:

In this experiment, the optimization tracking was done to get the most potent trapping of the beams. The diameter of the laser that enters the aperture of the microscopic objective is always kept correctly. There was a relationship between the laser being steep at the center and the laser having the central axis of the coming area. Due to that reason, the laser beam has no chance of getting diverted or the change of the path where it is going to strike. Also, there are chances to get distracted from the path where it originates that is because of the transfer of the momentum between the laser beam it passes through; it creates an impact on the mirror or the final results. It happens due to one lens that catches the particles by capturing some of the changes in the beam profile. As a result, there was an alteration of the energy, and it was redistributed in the edge part of the laser beam. The light that passes through the lens there we can see the profile of the ring was changed, and the ring around the center was created automatically. The helium-neon laser absorbs the power of transformation, and the wavelength is 632.8nm. The total energy that was consumed was measured first, and the center of the beam was blocked, and then the strength of the ring was measured last.

	Energy
Center	65.8%
Ring	34.2%
Total	100%

Table 1: The Total Energy.

In the table, 34.2% of the total energy is again diverted to the center of the ring. Adding to that, the entire energy front and back of the lens, the energy distribution of the beam, can be seen.

	Energy
Before the lens	100.0%
After the lens	97.6%

Table 2: Experimental Value and The Energy of The Laser Beam.

Where Table 2 gives the experimental value and the energy dissipation of the laser beam when it

passes and strikes the result screen. The period that is time taken for the frame advance is about $1/30$ of a second. This can be identified with the viewing of the image that alternatively changes in the resultant screen regularly with a known period and the advance depression frame counting that was needed to move forward through a full timing. For this, the second hand of the wristwatch is an example.

- Eye Detection Using Histogram Matching for Cornea Localization in Refractive Eye Surgery

First, Refractive Eye Surgery is a very sensitive and risky surgery because of its critical operation position. Using a laser will correct the sight level and decrease the risk of operating because of its remarkable and useful features. The laser will automatically target the eye and the energy to the corneal surface. A new detection method is proposed using template matching in order to localize the targeted eye to be corrected by the excimer laser. The template matching will guide the excimer laser in performing the surgery then the image guide will measure the distance between the corneal surface and the excimer laser. This technique will decrease the missing trials of operation and reduce the time consumed in the surgery.

Introduction:

LASER stands for Light Amplification by Stimulated Emission of Radiation. Laser is a special case of light. It is produced by the excitation of the atoms, which results in photons that create a narrow and focused beam called a laser. Laser is not a natural phenomenon; instead, it is an artificial creation. The theory of laser was first figured out in 1958, and then it was created in 1960. It was first used in thrilling movies such as the James Bond series of movies to increase the excitement of the audience. At that time, people were unaware of the power behind this remarkable creation. Its features reveal the power of the laser, where it has both coherent and monochromatic waves.

Laser has a single color and a wavelength that has a single frequency. These features allow the wave to travel in the same phase, giving it its attractive bright color. In addition, it will create a powerful energy in any specific area whether it is wide or small. As the theory of laser is in progression, the range of its applications is expanding from diamond shaping to monitoring the atmosphere on Mars. The region of applications that were considered is in the medical sector. As technology and examination methods are developing, precise and delicate operations are needed. Laser, with its remarkable features, is the best candidate to fill this position. Nowadays, surgeries, skin whitening, pigmentation treatments, dissolving body fat and more medical applications are done by different kinds of laser depending on the amount of heat wanted. Refractive eye surgery and laser speckle contrast images are two important applications that will be discussed in this paper.

Laser plays an important role in refractive eye correction surgery. A new application is proposed to improve eye tracking for this surgery. This application localizes the eye target to measure the distance between the cornea and the inputted laser. An algorithm of the gradient histogram matching

HOG is integrated to perform an excimer laser surgery interment called MICRON-M7. This instrument consists of a microscopic camera that has an X/Y motor of a laser head to automatically scan the eye and detect it to find if it is the right or left eye to do the necessary measurements [2].

The machine is not fully accurate, so it has the feature of being used manually to move it and place it in the center of the cornea by the surgery doctor. HOG is a technique that figures out the shape of the eye using laser identification that is transferred into pixels. It has a matching template that contains eye images to compare with. There are three programs that deal with this technique, which are MICRON, CASIA, and UTIRIS. The eye images are represented in grey color, and the darkest spot represents the center of the cornea. After detecting the eye and figuring out its shape from the matching templates, a red line will be projected on the corneal surface and reshaped in order to correct the eye's sight level. The excimer laser will strike the corneal surface and reduce its curvature to enable the light to enter properly and focus into the retina for clearer vision. The matching template method with MOG is a progressive and useful method that is used to assist the excimer laser in performing refractive eye surgery and reduce the risk.

- Multi-Scale Entropy Study of Medical Laser Speckle Contrast Images

Laser speckle contrast imaging LSCI is an extended field of optical imaging technique to monitor the micro-vascular blood flow map represented in the 2-D image. LSCI data is a new imaging technique compared with the laser Doppler flowmetry data LDF. LDF presents the micro-vascular blood flow map in a 1-D image. Both techniques study the micro-vascular changes that happen in the tissues. Laser is a main factor in performing these two methods. In this paper, these two techniques of imaging will compared using the multi-scale entropy MSE. MSE is a method that is used to measure the complexity of any data set for a finite length of time.

Monitoring the micro-vascular blood flow is a very interesting and important clinical routine and research. It is used in many medical fields, such as dermatology, ophthalmology, and neuroscience. The new monitoring technique LSCI has increased the attention of the medical department with its 2-D imaging feature. LSCI uses coherent laser light to illuminate the random speckle pattern into a 2-D image [1]. Then, the camera will screenshot the blood flow map. Moreover, LSCI has a very good resolution compared with the LDF. LDF will send the laser photons to reach and strike the blood cells and reflect back. The photodetector will receive this action and generate a dynamic speckle pattern as a 1-D image. MSE data analyses for the LSCI are not completed yet. As a result of the current time analyzing, LSCI has a good spatial and temporal resolution and in addition of excellent reproducibility because of the scanning beam used. Moreover, LSCI has more in-depth analysis than LDF. LSCI laser expands over a much larger area in comparison with the LDF, and that will reduce the density of power. In conclusion, LSCI is a very progressive technique for monitoring micro-vascular blood flow maps. It needs more research and testing to reach the result of the comparison.

Conclusion

Optical tweezers (or laser tweezers) are highly sensitive instruments used to study cells, different types of molecules, as well as any form of sub-nanometer transpositions of the dielectric particles.

The optical tweezers have several advantages and disadvantages. Firstly, K. Heyman explains that laser tweezers allow micromanipulation of small particles such as molecules, and this was impossible before this invention [12]. Secondly, the tweezers allow the detection of the smallest motions of particles. There are works reporting about the distance of less than 3.4 angstroms. Additionally, laser tweezers are crucial tools in accurately measuring the position of the particles. Meanwhile, some of the disadvantages associated with laser tweezers include the complexity or sophistication of the instruments. The intensity of light distribution influences the performance of the optical tweezers [10]. They also have practical issues, such as the range of force that must be applied for them to function properly.

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