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Late Advances in the Field of Low-Vision Telescopes and Distance Magnifiers: A Review.

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Abstract--

Purpose: *Telescopes have drastically changed the way of low vision care and improved the living of visually impaired. But, we think low vision telescope has not reached its full potential in health care mainly due to a lack of knowledge on newer technologies and lack of translation. Although telescopes are well known among the practicing community, a proper work for compiling the newer telescopic technologies and advances into a single paper has not been done yet.*

Methods: *We have compiled all the late advances observed in the field of telescopic technologies and magnifier from the period 1984 to 2017 from a collection of 37 articles. We obtained literature materials mainly from five broad sources 1. journal article databases (24 articles), 2. online journals (6 articles), 3. publication archives of eye care association (2 articles), 4. online archives for eye health products and websites (3 Articles) and 5. offline materials such as books (1 book).*

Result: *We found that telescopes have a significant effect on people's lives suffering from low vision. There are a couple of technologies and ideas which can be translated into new telescopic products. We also found a trend in research trying to miniaturize existing telescopic technologies and experiment with augmented reality.*

Conclusion: *There is a long way before the main hurdles of cosmetic appeal, cost efficiency and availability are overcome. Some solutions are visual multiplexing, automated focusing techniques, ergonomic designs, miniaturized telescopes, development of better and stable materials.*

Keywords--*Low Vision, Low Vision Telescopes, Blindness, Low Vision Aids, Magnifiers, Visual Impairment, Galilean and Keplerian Telescopes.*

I. INTRODUCTION

Low vision is a very prominent term in the field of vision rehabilitation and ophthalmology, According to World Health Organization's definition "Person with low vision is one who has impairment of visual functioning even after treatment, and/ or standard refractive correction, and has a visual acuity of less than 6/18 to light perception or a visual field of fewer than 10 degrees from the point of fixation, but who uses, or is potentially able to use, vision for the planning and/or execution of a task"(Dijk, 2001). According to the*International Statistical Classification of Diseases, Injuries and Causes of Death, 10th revision (ICD – 10): H54,* low vision means anyone

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with a “visual acuity that is equal or less than 6/18, but equal to or better than 3/60, or a corresponding visual field loss to less than 20 degrees in the better eye with best possible correction”(Resnikoff et al., 2004).

The first work on global data in the prevalence of visual impairment was made in 1995, based on the data recovered in 1990 (Thylefors et al., 1995). Based on this data further extrapolations were made for 1996 and the 2020 world population, which eventually lead to the global initiative for preventing avoidable blindness and came to be known as “Vision 2020: The right to Sight”(Resnikoff et al., 2004). World Health Organization classifies both blindness and low vision into visual impairment, whereas blindness by its definition means “a person with a visual acuity less than 3/60, or a corresponding visual field loss to less than 10 degrees in the better eye with best possible correction”(Resnikoff et al., 2004).

By the year 2002, almost 124 million people were suffering from low vision throughout the world,and the ratio of the people with low vision to those with blindness by the WHO sub-region basis ranged from 2.4 to 5.8 with median of 3.7 (Resnikoff et al., 2004). It was stated in the Global Estimate of Visual Impairment by WHOthat the prevalence of low vision in the world is two percent(Resnikoff et al., 2004).

It is to be noted that individuals with blindness (by definition) could mostly be helped with rehabilitation services only, whereas individuals that are categorized under the low vision category could also be provided with low vision aids to enhance or sometimes bring them near to normal functional vision capacity, these individuals are like “people who could avoid a flue from getting wet in rain using an umbrella”. It has been established in many studies that low vision devices, in general, have a significant improvement in overall functional abilities, especially in children(Gothwal et al., 2015). Many more studies suggest that low vision aids have been beneficial to 80-90% of the population who are prescribed with low vision devices (Leat et al., 1994), (Gothwal et al., 2015).

Ninety percent of the worlds visually impaired are living in the developing countries, but still, low vision services are not available for them and even if reached its affordability is still a question for most of the visually impaired communities (Gothwal et al., 2015),(Lamoureux et al., 2007). The above statement is quite felicitous to a study at LVPEI, where it was observed that only 39% of the total population of visually impaired individuals acquired low vision aids which were prescribed to them during the study (Gothwal et al., 2015). It is estimated that less than 10% people coming for low vision services (LVR’s) are using the visual aids prescribed to them (Gothwal et al., 2015). The above-mentioned studiesapprises us to conclude that there is a large gap in the distribution of these services. So, this is a very sensitive as well as impactful region towards which a lot of research is dedicated (Gothwal et al., 2015).

Telescopes are in use by the public since 1608, and eventually, the potential of the telescopes were discovered by low vision practitioners. There had been many attempts and studies done to improve the conventional telescopes by altering the optics, design, manufacturing methods, mounting, usage techniques, prescription methods, etc. Studies has shown that the most frequently acquired low vision device is a distance telescope (Gothwal et al., 2015). In a study at the Department for Low Vision and Rehabilitation, LVPEI, it was noticed that low vision telescope prescribed for distance were the most frequently acquired low vision aid during the period of the study (Gothwal et al., 2015).

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There are many modern devices that can replace conventional telescopes, but still, conventional telescopes are the mainstream and standard devices prescribe by almost all the low vision specialists around the world, due to its simplicity and availability of materials requiring to manufacture it.

There have been number of research papers published since 1990 in the field of low vision telescopes; this provides us with enough material to understand the progress in the field of low vision telescopes, its past, present and future scopes of improvement. This paper attempts to cover all the developments and newer technologies that are emerging in the field of low vision telescopes including distance magnifying digital devices. According to our knowledge, there has been very minimal attempts made to compile all of the details mentioned aboveinto one work. Hence, this article is dedicated for future references by the researchers to understand the present scenario of research made in this field.

II. TELESCOPES: LOW VISION TELESCOPES, GALILEAN VS KEPLERIAN.

Telescopes works on the principle of angular magnification. Telescopes could be prescribed for distance, intermediate and near tasks as well, these help the patient to focus on details in the surrounding and use these information for navigation, skill development, copywriting, etc. According to Faye, 1984 a “telescopic system (TS)/Telescope is an optical instrument that improves/enhances the resolution of an object by increasing the size of the image projected on the retina, making it closer”(Faye, 1984),(Adamec, 1997).Patient suffering from AMD, Stargardt's Disease, Bardet-Biedl syndrome use telescopes as all these diseases cause loss of central vision which causes impairment of an individual’s ability to watch T.V, recognise faces, read texts and drive a vehicle(Peli, 2001). This is because central vision is responsible for acquisition of high-resolution images(Peli, 2001).The visual system of humans has evolved to an extent that it provides us with a wide field of view which is almost 180 degrees horizontally, with a high resolution of 1 minute of arc(Peli, 2001).

There are telescopes that could be focused manually and those which already is under stationary focus, two of the most popular methods of making a telescopic system are the Galilean telescopic system and Keplerian telescopic system(Michelle Beck, et al., 2011.). Galilean telescopic systems has a big convex objective lens of higher magnification and a smaller concave subjective lens which produces a magnified, virtual and erect images(Katz, 2004),(Michelle Beck, et al., 2011.), They are lighter in weight and have a shorter barrel when compared to Keplerian telescopic systems, and are available in lower magnification power range(2X to 4X)(Michelle Beck, et al., 2011.). Keplerian telescopic systems utilizes the magnification of a convex lens as the eyepiece and objective lens and use prisms or mirrors to invert the real and inverted image. These are available in powers from (3X to 14X) and the barrel of Keplerian telescope is longer and comparatively heavier than corresponding powers that use Galilean telescopic design, and produces larger visual field and better optical quality than Galilean type and costs more(Katz, 2004),(Michelle Beck, et al., 2011.),(Galton Vasconcelos, &Luciene C. Fernandes, 2015).

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III. CONVENTIONAL DESIGNS, ADVANTAGES AND DISADVANTAGES

Galilean and Keplerian telescopes are given many different formats of prescription including handheld, clip on and spectacle mounted telescopic systems. Hand held telescopes are the cheaper and lighter in weight and are considered as primary prescription device for low vision patients, monocular telescopes are indicated to those individuals who have significant difference in visual acuity in both the eyes and binocular telescopes are indicated in case of individuals with almost same visual acuity in both the eyes, so as to enhance the binocular visual acuity and utilize the available field of vision to the fullest. But in turn all these weigh more and are expensive when compared to the functional output(Galton Vasconcelos, &Luciene C. Fernandes, 2015).

A fixed focus telescope is prescribed for individuals suffering with diseases/syndromes that causes poor motor coordination in them, according to current scenario the prescription of stationary focus telescopes has ceased and children are preferring more of the adjustable focus type telescopes. Due to its bad aesthetic properties, difficulty in usage and high cost the telescopes are not universally accepted(Galton Vasconcelos, &Luciene C. Fernandes, 2015),(Peli, 2001).

Watson’s research pointed out the optical and ergonomic aspects as the reason for the discontinuation of the low vision devices. Apart from that he specifically pinpointed at the range, image details, inability of automatic focusing abilities, contrast and brightness as the major drawbacks that effect the popularity of the conventional low vision devise(Watson et al., 1997). But, to put it blunt, we could say that all the above-mentioned devices comes under the conventional category of the telescopes which has been used around the world since long time, and has passed the test of time until now.

IV. PREVALENCE OF TELESCOPE USE IN PATIENTS

In children, “the prevalence of blindness varies from 0.3/1000 in high-income countries to over 1.0/1000 in low- and middle-income countries, equating to around 1.4 million blind children worldwide”(Barker et al., 2015). And according to some extrapolations low vision is double the amount of blindness and can affectup to 3 million children worldwide(Barker et al., 2015), this concludes the fact that requirement of low vision aids are necessary in the present and coming future. Telescopes play a vital role in the rehabilitation and visual performance enhancement to support the academic section of the community which includes learners and teachers alike. Proper low vision rehabilitation is required, if a country wants to get the full efficiency out of these individuals in the society who would otherwise be left alone.

In the study by Elliott et.al, it was seen that the primary objective of an elderly individual suffering from low vision was to able oneself with reading and orientate in vision-related daily living activities(Elliott et al., 1997). In the case of children with visual impairment, this takes a different purpose and turn. Many studies including Tobin et.al, and Troster et.al., considers this group (children) of the society as vulnerable, cause vision impairment in these group effects their education and their status in the society(Tobin et al., 1997),(Troster, & Heinrich, 2001).

In a study done at Kooyong Low Vision Clinic, University of Melbourne between (1972-1996), it was noted that the highest number of individuals who got prescribed with low vision telescope were between the age of

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0-29 years, this comprised about 21.4% of the total study population (initial sample of 22,860 individuals)(James S. Wolffsohn,& Anthea L.Cochrane, 1999). And the average age of the patient attending clinic increased from 71% of individuals with age ≥60 years in 1970's to 87% in the 1990's, which makes it evident that the need of low vision aids have increased over the period and that the requirement of telescope may increase in the coming times(James S. Wolffsohn, & Anthea L.Cochrane, 1999). This signifies the importance and prevalence of telescope among the children belonging to academic ages. But no known studies are done so far since last 5- 10 years that helps us to conform this claim, which just makes this an assumption as these arguments are based on extrapolated data.

Previously performed studies which involved testing low vision rehabilitation outcomes were performed by evaluating the contentment of the adult patient with the device and the same case summary implies to the testing of low vision telescopes as well(Gothwal et al., 2015). This was considered as a major impediment by researchers back then, as the data acquired were biased or are likely to embellish or disparage the product under the test by misconceiving the outliers. This has led many researchers to device their own questioners that are based on patient-reported outcome measures(PRO's) which involve evaluating patient's perception of ability before and after the induction of low vision aids(Gothwal et al., 2015). But these questioners were developed for assessing adults and were not efficient in assessing children.

In consecutive period developments happened in this field and studies such as the Gothwal et al, 2015, have attempted to devise LVP-FVQ II for assessing the effect of low vision rehabilitation which is one of a kind of a study. Apart from this, there are other PRO's which were developed by keeping children in mind(Gothwal et al., 2015).

The reason for less priority given to lower age population could be due to the myth that age plays a major factor in the acceptance of low vision aids. But, this parable has been busted long and it has been established that age and the visual acuity achieved with the low vision aid are not predictive to their continued usage(Harper, Doorduyn, et al., 1999),(Watson et al., 1997).

V. ADVANCES IN THE FIELD OF TELESCOPES AND DISTANCE MAGNIFIERS

It is seen that since past few decades many studies has focused on improving the functional quality of the vision rather than just improving the central vision which does not help if peripheral vision is not taken care of(Peli, 2001). The modern era of developing low vision device are based on breakthrough optics, composite materials, cutting-edge manufacturing techniques, market research and lesser known astronomical physics. This new field of research that combines both the central vision and peripheral vision by overlapping both on to the visual system, so as to decrease the visual load on the individual is known as visual multiplexing(Peli, 2001).

The sampling rate of images at the fovea is done at a higher rate than in the peripheral retina. All the information gets integrated into one single image by the brain into a navigational field(Peli, 2001). The loss of any one of the components of the visual system prevents the interplay of central and peripheral vision, all conventional devices including telescopes addresses these issues by replacing or supplementing the missing function, but it usually compromises with the residual vision(Peli, 2001).

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Similarly using a telescope decreases the peripheral field of vision that is responsible for navigational purpose leading to restricted mobility, so it becomes necessary to develop an instrument that suffices these needs. Visual multiplexing shows quite a promise when it comes to utilizing both peripheral and central vision to its fullest(Peli, 2001).

But it has been seen that there are already a lot of devices in the market that utilize the concept of visual multiplexing even before the study made by Eli Peli in 2001.Bioptic telescope is one of the most popular devices that is being used by individual drivers who are suffering from low vision across the United States. According to Bowers et al., 2005 almost 34 states in USA allows the usage of bioptic telescopes for drivers with low vision and according to Owsley et.al,2012 it has increased to 43 states. Some of the early studies shows that 2.4 million Americans over the age of 40 years have best corrected visual acuity worse than 20/40, but better than 20/200 making them eligible for driving with the aid of bioptic telescopes (Owsley, 2012),(Bowers et al., 2005).

By now it is clear that bioptic telescope are assistive devices for individuals with low vision that helps them to focus on sign boards on the road and provides relatively unrestricted driving habit. Bioptic telescope was initially build by Dr. William Feibloom(Owsley, 2012). “The bioptic telescope is mounted in the superior portion of a regular spectacle lens (referred to as a “carrier lens”) or above the carrier lens affixed to the spectacle frame”, the carrier lens is prescribed with the required refractive correction necessary for the patient or sometimes left alone with plano-power.(Owsley, 2012). The frequently used bioptic telescopes magnification ranges between 2X-4X with a field of view of 6-16 degrees respectively(Owsley, 2012),(Bowers et al., 2005).

According to Huss and Corn’s study done in 2004, it was noted that almost 4,000 to 5,000 members in United States are licensed with driving certificate who are using bioptic telescope(Corn & Huss, 2004). This gives us a positive remark about the usefulness about the device, but still it is far from making any claims about the effectiveness of the bioptic telescope as of now, since there has been no statistically significant data available to ensure the true extend of bioptic telescope usage (Bowers et al., 2005),(Corn & Huss, 2004),(Owsley, 2012). Furthermore, we know little about the approaches that are cost efficient, driver safety and driver performance (Owsley, 2012), and on the other end it has been shown in some studies that drivers with visual acuity between 20/40 to 20/200 are able to do satisfactory navigation on the road, maneuver at the turns and judge the gap in road. It is also seen that these individuals have the same safety records as of those with visual acuity better than 20/40.(Owsley, 2012),(Owsley &McGwin, 2010),(Higgins et al., 1998),(Peli, 2001).

In the year of 1964 and 1989 attempts were made and implemented on making a combined spectacle intra-ocular lens (IOL) telescope which had a high power negative intra-ocular lens (IOL) placed inside the capsule using a similar procedure done in a simple cataract surgery and a high power positive spectacle was worn, which acted like a Galilean telescopic system, this system was called the “Morcher System”.(Donn, Anthony MD; Koester, Charles J. PhD, 1986),(Peli, 2001), . In the successive years Allergan Inc. modified this system and reproduced the same by devising a bifocal IOL system, with the high negative power concentrated in the center and by wearing a high power spectacle power in front of the eye known as the Koziol-Peyman telescopic system.(Koziol et al., 1994),(Peli, 2001). But subsequent studies (Garnier and De Lega, 1992) showed that many individuals who

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participated in this study did not benefit from the telescope or rejected to wear the positive spectacle due to aesthetic reasons and in many of the other studies the patient did not receive the spectacle component to begin with(Garnier & De Lega, 1992),(Peli, 2001). This problem could be solved using temporal multiplexing by using a double bifocal IOL spectacle system which is patented by Eli Peli, where both IOL and spectacle lens are bifocal thus dividing the vision into telescopic in the upper half and normal spectacle correction in the lower part(Peli, 2001).

A company called VisionCare Inc. developed a completely Implantable miniaturized telescope (IMT), which could be placed directly into the posterior chamber (following a cataract surgery procedure) this small telescope is configured as a Galilean telescope and the major element that sets this system apart from the spectacle lens IOL telescope is the fact that the patient who underwent this procedure could wear their normal refractive correction, which compensates the ascetic factor of the previous device (Peli, 2001),(Tabernero et al., 2015),(Peli, 2002). The act of magnification inside the eye "eliminates all the problems that conflicts with increase speed of motion of the objects in the surrounding and vestibular conflict that impede the use of other head–mounted low vision telescopes"(Peli, 2001) (Peli, 2001), "IMT provides a nominal magnification of 3.0X and a field-of-view of 6.6° (9.2° for the 2.2X magnification version)"(Peli, 2002).

Some studies show that the Effective field-of-view which is formed by (field of view and field of fixation) gets effected by lager magnification that conflict with the head motion and the increased image motion, vestibular reflex and disruption of stereo-depth perception of human, but the study (Peli, 2002), shows that these issues can be manageable with a IMT(Peli, 2002).

In the following study by (VisionCare Inc.), the tests and evaluation of the device was done in patient who were planted monocularly with IMT (2.2X magnification model) in the worse eye. This restricted the achievement of full binocular evaluation test to validate the effectiveness and full impact of the device on these patients(Peli, 2001), But on contrary this helped patient those who had relatively lower vision in both the eyes, as they used the implanted eye for watching T.V. (High resolution task) and the fellow eye for mobility purpose which is a low resolution task(Peli, 2001).

In the previous mentioned study which involved visual multiplexing the author came up with an idea that, using a partial occulder made from a frosted tape on one of the spectacle lenses in-front of the fellow eye (Non-implanted eye), the implanted eye could be used for viewing fine details of the target, as a telescope that is implanted inside the eye would not be able to collect enough light due to its small entrance pupil, thus creating a situation of binocular rivalry. Binocular rivalry is a condition cause due to presentation of dissimilar images to both the eyes which produces a conflict between both images in the brain, creating alternation in the perception of image presented between both the eyes(Tong et al., 1998),(Liu et al., 1992).

Advances in the field of IMT technology happened after the introduction of aspheric implantable miniaturized telescope that has a "significant advantages in optical terms, such as the tolerance to different axial lengths and the increase in depth of focus". This device is only available in single design as per the study with two decentered high power positive and negative lenses of +66 diopter and -66 diopter power respectively. It is incorporated with a prismatic effect of about 3 degrees also incorporated to project a magnified central field of view

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into a healthier location off the central fovea, aspheric surfaces is devices to make sure that a good quality surface optics is achieved along with good surface tolerance(Tabernero et al., 2015).

A study on inbuilt spectacle lens system was published in the year 2002, this claimed to have relatively larger field of view, higher magnification and brighter image quality(Peli, 2001). This system of incorporating a telescope configured with a Keplerian telescopic system was known as an In-the-lens-telescope (Peli, 2001),(Peli& Vargas-Martín, 2008),(Peli, 2002). This device has a beam splitter, periscopic mirror system, Quarter wave plate and a Keplerian telescope system (Peli, 2001),(Peli& Vargas-Martín, 2008),(Pelia& Vargas-Martína, 2002). One of the main reasons of developing this system was to replace the factor responsible for the constant rejection of bioptic telescopes. Which was due to its smaller field of view and also the obvious and unsightly appearance of the device (Peli& Vargas-Martín, 2008),(Peli, 2001). This was addressed with a Keplerian design in the in-the-lens-telescope(Peli& Vargas-Martín, 2008). In many ways this device is optically advanced to that of a bioptic telescope, as the distance from the aperture to the eye is reduced due to the increasing the angular span of the field and also the dimension of the limiting aperture is not affected by the magnification(Peli& Vargas-Martín, 2008),(Pelia& Vargas-Martína, 2002). But in contrary it has been seen that since the telescope covers almost aprox.80% of the spectacle plane and “the carrier lens as a flat lens on both sides and thus could be used only by individuals without any refractive error (emmetropes)”(Peli and Vargas-Martín, 2008) (Peli& Vargas-Martín, 2008),(Pelia& Vargas-Martína, 2002).

A Bilevel Telemicroscope Apparatus or BITA is a new version of Galilean telescope that is very small in size and provide improved field of view, image quality and spatial orientation compared to conventional spectacle mounted telescopes, in a way it belongs to the category of micro-telescopes.(Peli, 2001),(Harkins &Maino, 1991). Micro-telescopes help in visual multiplexing by shifting the magnification scotoma ring above and below the field of view of the telescope, that is mounted on the carrier lens(Peli, 2001),(Harkins &Maino, 1991). Microspiral Galilean telescope could be mounted in either the full diameter of the carrier lens (Spectacle) or in the bioptic position mounted at the higher regions of the spectacle(Feinbloom, 1991). Almost all forms of spiral Galilean telescopes come under 1.7X to 4.0X of magnification. This versatile device helps patients to focus from near point of 12 inches to infinity (Feinbloom, 1991).

The most noticeable and evident advantage of a digital device over any conventional low vision device is its ability to produce high magnification along with a relatively larger and aberration free field of view(Harper,&Doorduyn, et al., 1999). And, this is the reason why we could tell that the modern research flow should happen in the direction of newer digital mounted devices that has the capability to replace LVD’s such as conventional telescopes. But on contrary to this, studies like Goodrich et al., 1981 states that reading speeds are not influenced much with the use of CCTV’s when compared to a non-digital approach, although the duration of use was significantly influential(Goodrich et al., 1981).

In a 1999 study by Harper et al., an LVIS (low vision imaging system) known as a head-mounted video magnifier was propounded, which was developed at Johns Hopkins University. According to their description, the device consisted of mains/batteries, a video display head-mounted device, an auto-focus camera, variable

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magnification optics and electronics that enhances contrast (Harper, & Culham, et al., 1999). The device operates on two video cathode ray tubes which are mounted at the temples on each side of the device. The image is magnified using aspheric lenses and projected on to the front of the eyes with the help of mirrors and beam splitters(Harper, & Culham, et al., 1999). This device gets the input feed through two monochrome charge coupled cameras that are mounted in the level of the visual axis and a single center mounted camera with zoom capability is used to supplement near vision tasks(Harper, &Culham, et al., 1999). The center mounted camera has autofocus capabilities along with a tilt range of 45^{O} and produces 10.5x magnification for near. Although this is a groundbreaking technology, it is still quite sizeable in construct and the patient requires to carry a battery bank along for daily operations(Harper,&Culham, et al., 1999).

A similar technology known as Aurora imaging system was founded during the same period as the LVIS, but had a better magnification compared to an LVIS due to is the construction which involved the use of color cameras and Liquid Crystal Displays (LCD's). This device was commercially known as the V-max and featured a docking stand which allowed the device to be used like a CCTV in conjunction with a monitor(Harper, &Culham, et al., 1999).

Even though these devices were versatile in their job but couldn't reach an affordable market range and cost easily from 3000£ to 4000 £ per device(Harper,&Culham, et al., 1999). And individuals who could clinch these devices would further have to deal with potential problems like motion sickness and claustrophobia, summing to these flaws are its inability to serve for patients with head tremors and individuals who are physically unable to operate these devices(Harper,&Culham, et al., 1999).

VI. TRANSLATIONAL RELEVANCE

Telescopic systems as we know have several limitations in terms of its design, availability, optical properties, ergonomics, and also the general popularity amount the low vision community is highly debatable. Though telescopes and distance magnifiers have been in research since few decades there has been no serous breakthrough that has happened until recent years. Development in the field of virtual reality, composite material, augmented technology, software, computer processors and availability of complex technologies has opened up a lot of windows for improving the existing telescopic and head mounted devices.

I can be argued that significant changes in refractive material technology such introduction of thinner glass materials with high refractive index has made the lenses lighter, but this has not translated well to improve the optical qualities of telescope. On the other hand, introduction of multiplexing and augmentation has actually contributed well in the development of telescopes and distance magnifiers, by drastically improving the visual and mobility outcome of subjects suffering from low vision. The research and observations made by Ellie peil,.et al, have been of great significance and highlights the need for extensive research in the area of visual multiplexing.

There have been efforts made to improve the overall quality of image and reduce aberrations, despite all these efforts the field of view has always been a limiting factor with telescopes and also the range of magnification.

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And it is here the distance magnifiers take the lead, as unlike optical telescopes displays can be configured using software and image processing techniques.

In Carmelo., et al, they discuss about a video enhancing technique for geriatric individuals suffering from low vision arising from scotoma caused by Age Related Macular Degeneration. The proposed vision-aiding technology produces video stream captured and rendered through 3D image processing, capturing techniques and then displays correction adjusted images in real-time on to stereoscopic displays. The author claims that the system comprises of a very robust visual enhancing software that can be tailored for each individual separately.

We could say that research in the current scenario is pushing newer methods and ideas for improving the lives of low vison patients. But there have been no extensive human trials or data collection made to support the translation of these products into commercial market. And, it could be concluded that techniques like visual multiplexing, image enhancement, intraocular telescopes and in -the-lenses telescopes should me researched upon and translated well.

VII. CONCLUSION

Prevalence of low vision is a major concern in almost all parts of the world, and the most effected age group with low vision are the individuals of age between 0-40 years. This is the most productive age group in the population if we consider their age distribution pyramid of a country, and they are expected to earn a living of their own and support the community at their possible levels. These individuals require assistance at various levels of their life and one of the requirements is in the field of education. And, the most affected are those whocould only attend regular schooling system, due to lack of special schooling facilities in their respective country.

One of the leading factors of low vision is the impairment of central vision which could be caused due to diseases like macular degeneration, which has become quite prevalent in the current scenario. Telescopes play an important role in patient with central vision defect, and able them to view details of the target at moderately high details. Watching T.V, reading, writing and recognizing target requires central vision to be intact. Conventional low vision aids can only enhance one component of the vision, this makes them highly task-specific (Harper, & Culham, et al., 1999). So, newer technologies like multiplexing and augmented display technologies are the stone-setters of the coming period.

In this article, we have tried to incorporate all the previous conventional practices of telescope to the latest advance that is happening in the field and suggest fields of translational relevance that can improve the existing telescopic and distance magnifier devices. Many studies are done on drivers across the United States who use bioptic telescopes to navigate around, these studies have increased our understanding towards the effect and impact of low vision telescopes in the daily life of individual drivers who are affected with low vision. This review has helped us to formulate the fact that most of the problems faced by the individuals using conventional telescope could be corrected by incorporating newer technological breakthrough which is happening in the current world.

But still there aren't sufficient information on whether these technologies are utilized properly and there aren't either any data stating the availability and distribution of these technologies in the market worldwide. It could

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be understood that most of the technologies are expensive and limited to individual preferences. There have been no reported studies that shows us the effects and advantages of long-term use of telescopes either.

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