Optical method and elements for deviated view mobile cameras

Abstract: often people use their mobile phones for texting , browsing , searching and emailing while walking. To avoid collision with other objects, animate and inanimate, or to avoid obstacles and holes on the ground, it is necessary for them inconveniently to occasionally divert their attention to their surroundings. Still , mishaps happen. The solution is to have the video camera used while walking so the field of view in front of the walker is shown on his phone display. While solutions under "walk N talk" are sold, they require the walker to hold the camera at its vertical position which is not convenient

This invention provides for a specially designed small prism placed in front of the camera to allow walking and texting while the scene in front of the walker is shown on his video camera and the camera is held at a convenient angle of 45^0 or 60^0 from the horizon.

Background of the invention:

Walking and texting is also called "walk and type" ,"mobile Zombies" and other names.

An excerpt from one of the many references on the internet:

...."As part of the study, the researchers asked 26 volunteers to walk into a hallway while texting. During the experiment, their movements were tracked using a number of camera and reflective markers were put on their bodies to keep track the different body segments' position.
Results show that those who were using their phones while walking tend to lock all their body segments, have a stiff gait and veer off a straight path. In addition to that, 35% of the volunteers admitted that they had already tripped or fell while using their phones frequently.
Siobhan Schabrun, co-author of the said research, suggested that see-through phones or text dictation feature can somehow lessen the accidents that occur from the habits of texting while walking. However, technologies as such should still be tested thoroughly to make sure that it really helps rather than giving people more distractions and health risks.
For now, it is greatly advised to always be cautious and as much as possible, never walk while using mobile phones.

also in another study:

Type While Walking: Never Take Your Eyes Off Your iPhone

Nov 01, 2010 6:50 PM EST | 0 Comments

By Alan Henry

From the "I can't part with my phone even for an instant" department comes an app that promises to let you keep your eyes on your iPhone at all times, even while you're walking around in public. Type While Walking allows you to compose SMS messages, e-mails, and other documents while on the move, and the app uses your iPhone's camera to create a live background on your iPhone's screen so you see what's in front of you while you type.

The app makes your iPhone work like a heads-up display, with white text on top of the view through your camera's lens. This way you can keep walking, type your e-mail or text message, and still see the car that's headed towards you before you step out onto the street.

It has been suggested that the users would **have the video on**, while walking , shown on the screen as the background or on one portion of the screen, and that the phone would be held essentially vertically to provide the view for what is ahead of the walker.

http://appscout.pcmag.com/apple-ios-iphone-ipad-ipod/269317-type-while-walking-never-take-your-eyes-off-your-iphone

from the same reference:

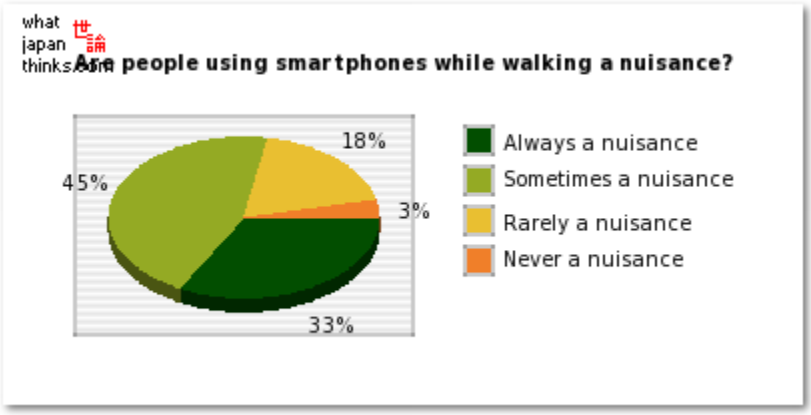
.."For the app to be really useful, you'll have to walk with your iPhone held vertically, directly in front of your face, so you can see everything in your normal field of view through the camera's lens. If you're like most people and hold your phone down and look down to use it, you're getting a fine view of your feet and the pavement as you walk.

Additionally, the fact that the app forces you to copy and paste your text into another app in order to work makes it difficult to recommend.

Even so, if you want to give Type While Walking (referred to as Type'N'Go in the app description but listed in the iTunes App Store as Type While Walking) a try, you'll need an phone running iOS 3.1 or later and a space $0.99 you're willing to spend on an app that may or may not be useful to you at all. "

This position- namely when the phone has to be held vertically with the camera pointed forward is awkward . People prefer to use their phones when at some angle off the horizon of 20^0 to 60^0.

More references to the problem at hand:

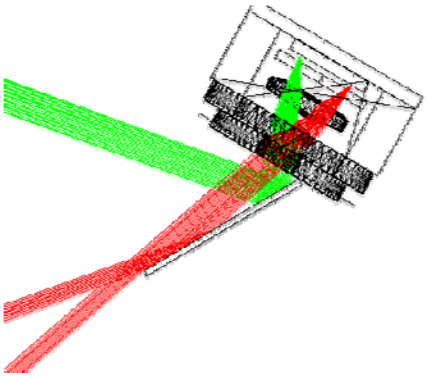


http://www.uq.edu.au/news/article/2014/02/text-zombies%E2%80%99-make-perilous-pedestrians-study-finds

other solutions: audio warnings :

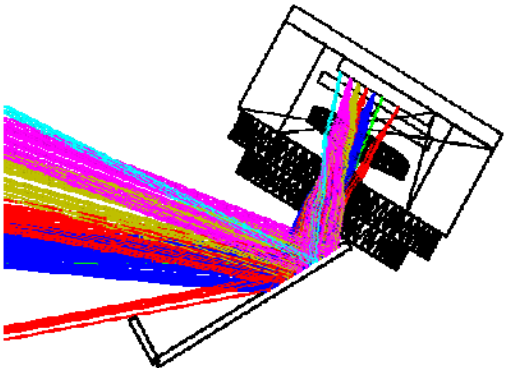
http://www.entrepreneur.com/article/231881

In the prior art, the solution proposed is to have the camera video running while texting and to hold the camera vertically which is inconvenient. One might suggest to use a mirror in front of the camera and deviate the field of view (FOV) as shown below:



However, a deviation by a mirror has three problems. 1. The mirror protrudes quite a bit making it vulnerable to damage. 2. The image is inverted so the video signal has to be modified provide image rectification and 3. Ghost images are hard to handle. In the above image two field angles (marked in red) converge at the same sensor location.

This last problem can be handled by adding a baffle as shown bellow which removes the ghost images but a cost of reducing the FOV and not solving the other two deficiencies of this mirror solution .



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Summary of the current invention

The current invention allows for usage of the mobile phone while walking and while still keeping aware of the scene in front by having the camera video displayed on the phone screen concurrently with the applications being used, such as for texting and browsing. In the prior art the walker cannot hold the camera at a convenient angle while walking since the camera will be pointing downwards . It is the main feature of this invention that a small deviating prism is placed, in front of the mobile camera, so the camera field of view is directed forward. The prisms are treated to prevent them from generating ghosts images. Means for easy placing and removing the prisms are disclosed.

Detailed description of the embodiments:

In the first embodiment per this invention, a $60^0/30^0$ prism is used to bend the optical axis of the phone camera by 60^0 as shown in Fig. 1. The camera shown is a typical mobile phone camera such as the one by Sunny Optics, a company in Zhejiang (CN) and disclosed in US2012/0050888A1.

This lens has an effective focal distance of 2.7 mm and F/2.3 and thus the entrance pupil diameter is about 1.2 mm. This number is quite typical for mobile phone cameras. The prism size is determined by the entrance pupil diameter and the field of view of the camera+prism system.

This prism does not introduce aberrations which might degrade the performance of the camera since the beams going through the prism are essentially collimated.

The prism entry and exit surfaces are AR coated. The bottom surface (Fig. 1b) of the prism is reflection coated since the angles there are not sufficient for total internal reflection (TIR).

The sharp corner of the prism can be rounded off or chopped as shown in

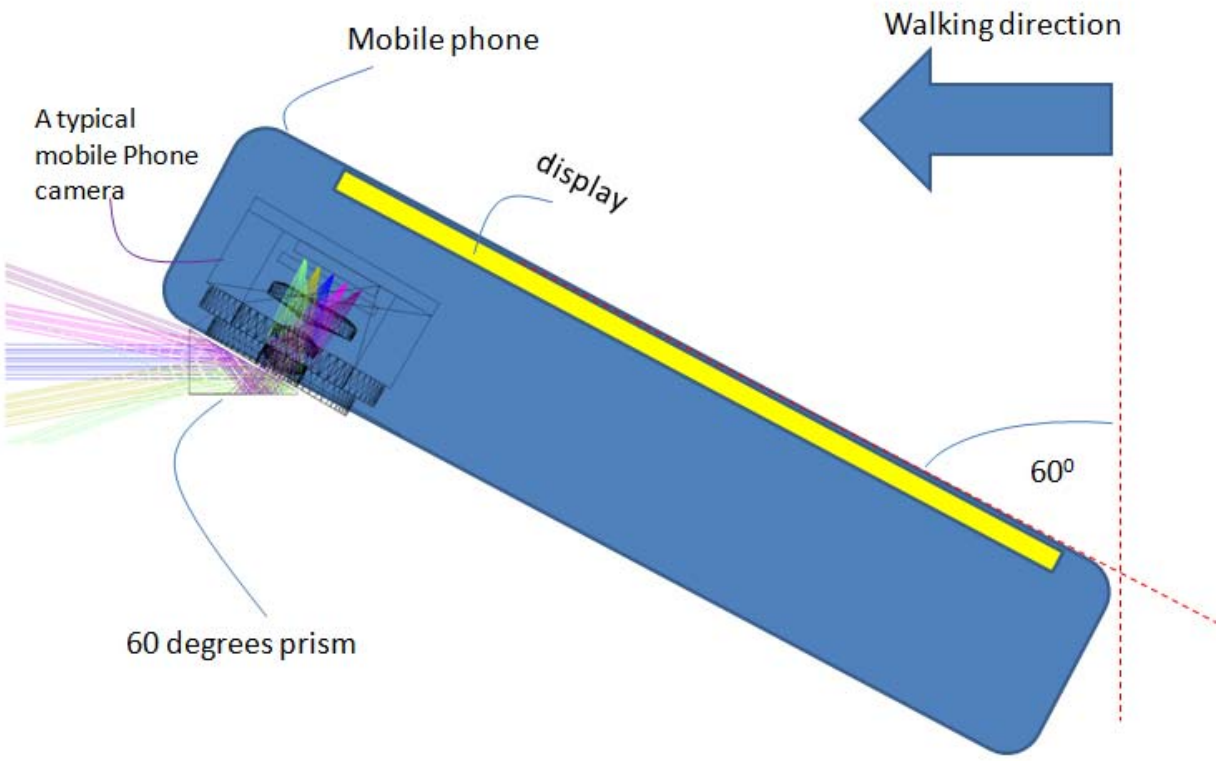


Fig. 1a: mobile phone camera with a 60^0 deviating prism

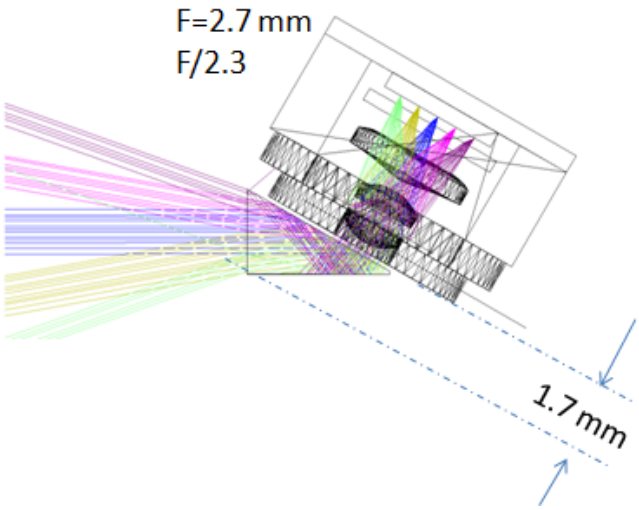


Fig. 1b: Extended view of the camera and 60^0 deviating prism. A typical mobile phone camera is shown with focal length of 2.7 mm and F/2.3 . The prism height as shown is 1.7 mm

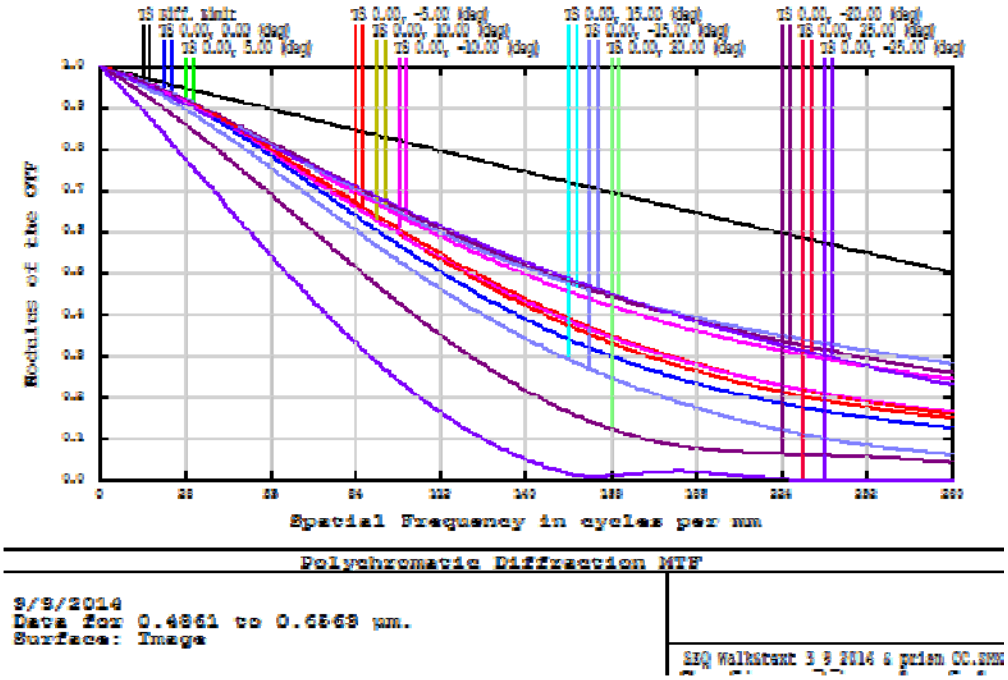


Fig 3: MTF of the camera and the prism

Fig. 3 shows the MTFs of the camera + prism system. The MTF curves are unchanged for most of the field of view. There is some degradation and the edge of the vertical fields (at $\pm 25^0$) due to the increased F number at these angles due to prism vignetting.

From the tunnel diagram of the $60^0/30^0$ prism shown on Fig. 4 we can easily get the value of the vertical field of view (FOV) of the prism. The FOV is determined as the 50% vignetting level , namely by the where the chief rays as shown on Fig.4.

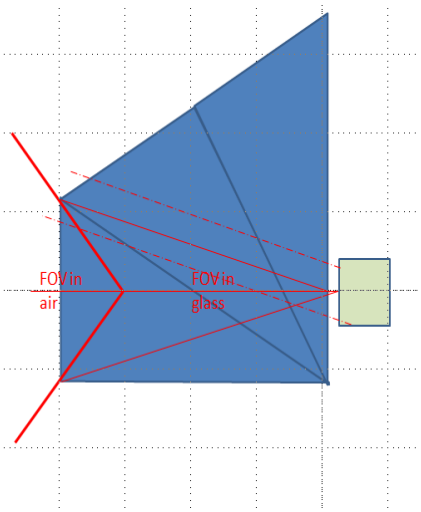


Fig 4: Prism vertical field of view and the prism tunnel diagram.

The FOV of the $60^0/30^0$ prism is dependent on its refractive index. Fig. 5 shows the dependence of the FOV on the refractive index. thus when we use for example a high index glass such as S-Lam66 with index of about 1.8, the FOV will be 59.9^0 . When Polystyrene is used, with an index of refraction close to 1.6, the FOV would be 52.7^0 .

Full FOV in degrees in Air as function of n

FOV is where we have 50 % one dimentional prism vignetting

FOV	n	nxsin(16.10211 deg)
47.426	1.45	0.402158
49.168	1.5	0.416025
52.688	1.6	0.44376
54.468	1.65	0.457628
56.263	1.7	0.471495
58.072	1.75	0.485363
59.898	1.8	0.49923

Fig5: The prism vertical field of view in air as a function of the prism refractive index.

The use of a prism to deviate the FOV has the advantage of not altering the parity of the scene since the prism is providing for an even (two) number of reflections so no video processing is needed as it would be needed in later embodiments using just a one reflection mirror instead of the prism.

Also , as evident from the prism tunnel diagram on page 4, the $60^0/30^0$ prism has its input and output surfaces both parallel to each other. This means that there would be **no field induced angular color dispersion**. Using a different prism wedge with an arbitrary deviation angle will introduce , as is well known in the art, severe aberration of lateral color at the sensor where the red green and blue images would be mis-registered.

The FOV of the prism calculated in Fig. 5 is verified by a non sequential ray trace on fig. 6.

The x direction on Fig. 6 is the sensor position in mm. (At 1.42 mm, the semi full field angle for this example of a camera with a focal length of 2.7mm is 27^0.).

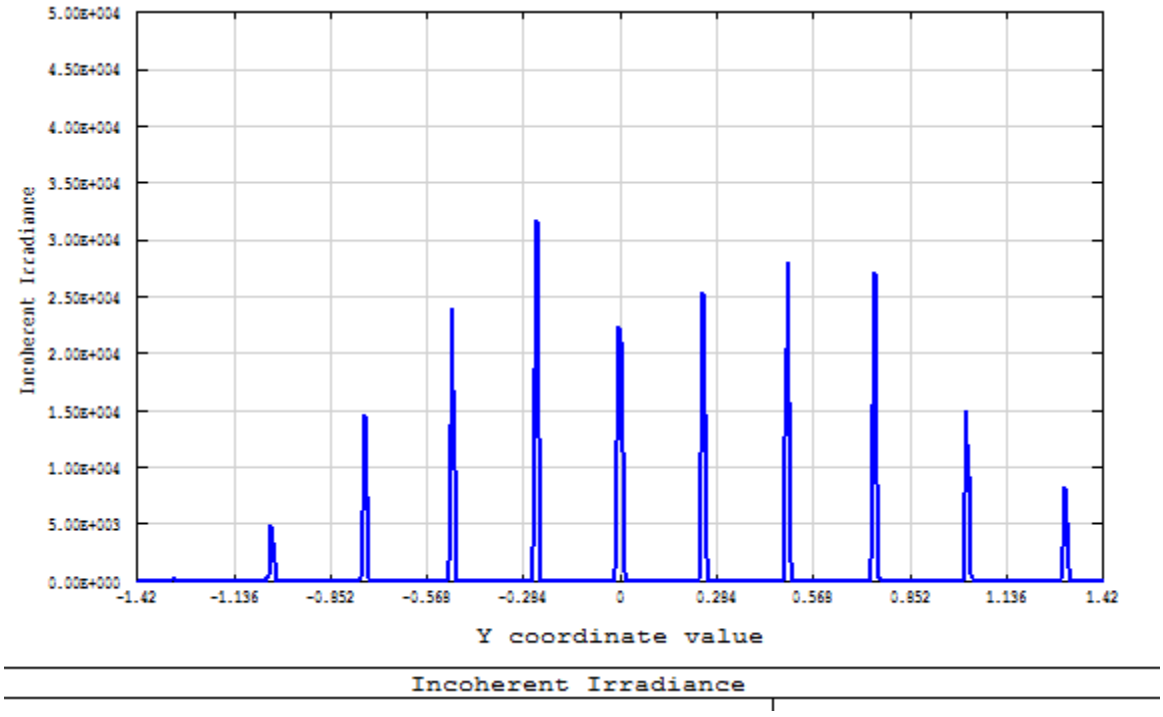


Fig 6. Field of view of the prism and camera . The x axis is the camera sensor position in mm. The non sequential ray trace shown at the camera sensor is for 10^0 field angles separated by 5^0.

Another feature of this invention is that the prism is partially coated with an absorbing layer to prevent unwanted reflection. As shown in Fig. 7a in addition to the wanted ray path of AB, there is for the same field angle another path, A'B' which produces a ghost image at the sensor. By adding an absorbing layer as shown on Fig. 7b, the A'B' beam is eliminated without affecting the performance of the prism over the FOV.

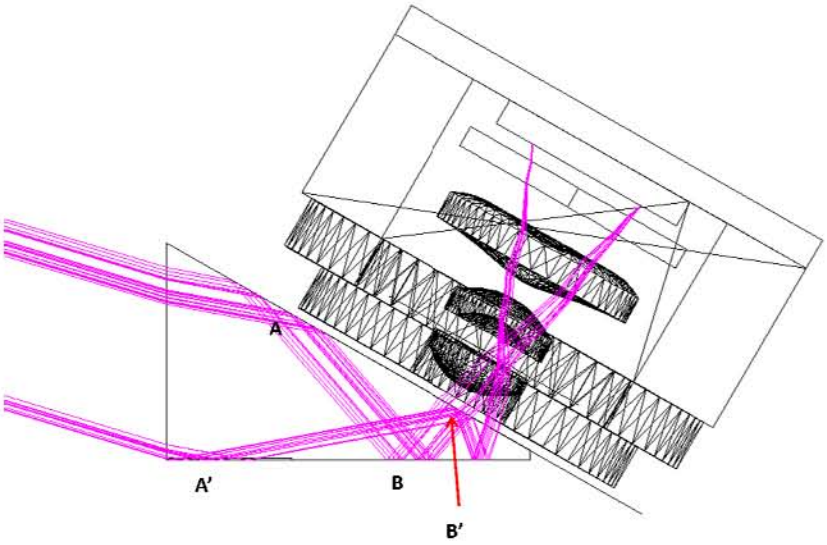


Fig. 7a: Potential double image .Same field angle produces two images at the sensor for the AB and A'B' tracks

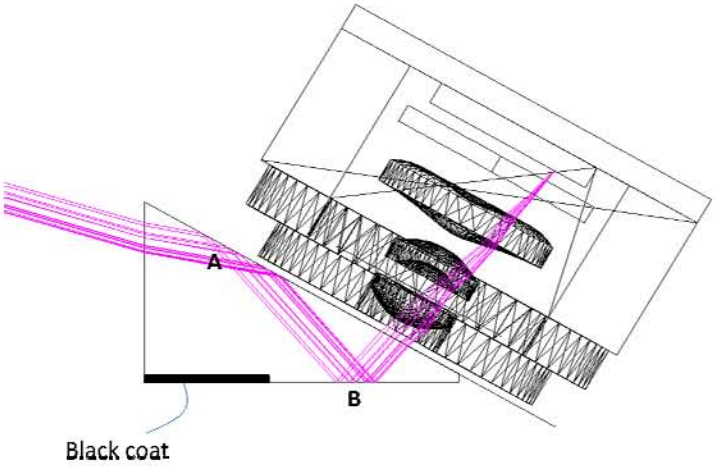


Fig. 7b: Elimination of double image with application of an absorbing coating .

Prisms are very effective and compact way to deviate the FOV. The example above shows the 60^0 deviation prism. One can deviate the FOV using prisms by any angle, but at the cost of introducing major color dispersion. There is only a small selected number of angles where prisms can be used effectively without introducing dispersion. One is the 60^0 prism already discussed and the other is the 45^0 deviation prism which will be discussed later.

Another preferred embodiment of this invention is when a 45^0 deviation prism is used as shown in Fig. 8a and 8b

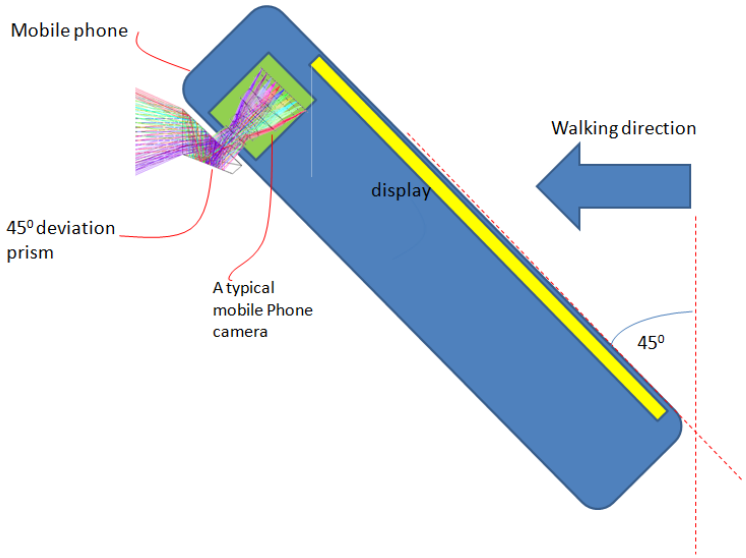


Fig. 8a: mobile phone with a 45^0 deviating prism

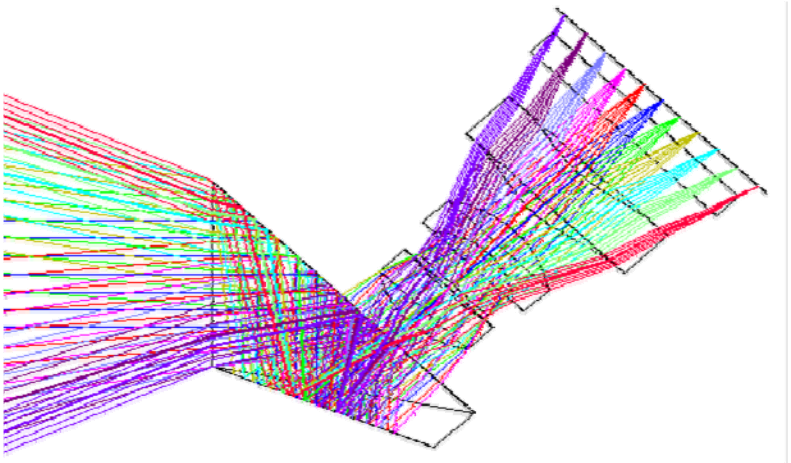


Fig. 8b: Expended view: mobile phone camera with a 45^0 deviating prism

The tunnel diagram for the 45^0 deviating prism is shown in Fig. 9 .

From it we can derive the prism vertical FOV for the prism as a function of the index of refraction of the prism shown on Fig. 10

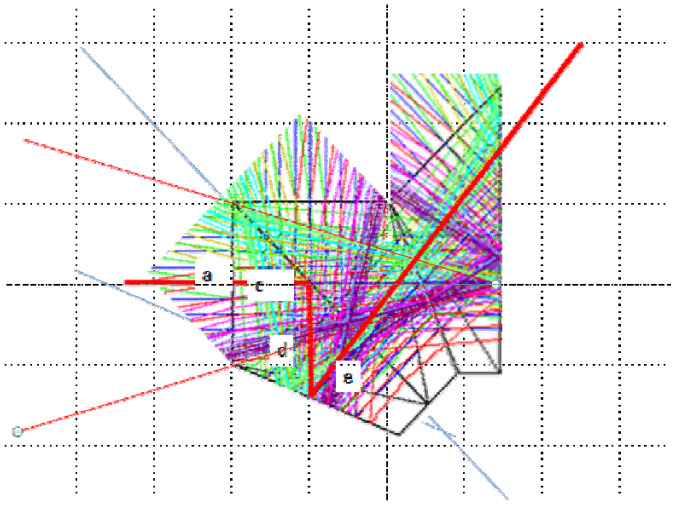


Fig 9: Prism vertical field of view and the 45^0 prism tunnel diagram.

Full FOV in degrees in Air as function of n

FOV is where we have 50 % one dimentional prism vignetting

	FOV	n
	48.105	1.45
	49.875	1.5
polystyr is 1.59	53.453	1.6
	55.264	1.65
seven degrees gain if we use high index g	57.089	1.7
	58.931	1.75
s-lam66	60.789	1.8

Fig10: The prism vertical field of view in air as a function of the 45^0 prism refractive index.

Another feature of this preferred embodiment using the 45^0 prism is that the prism is partially coated with an absorbing layer to prevent unwanted TIR reflection from the entry surface as shown in Fig. 11 a and 11b.

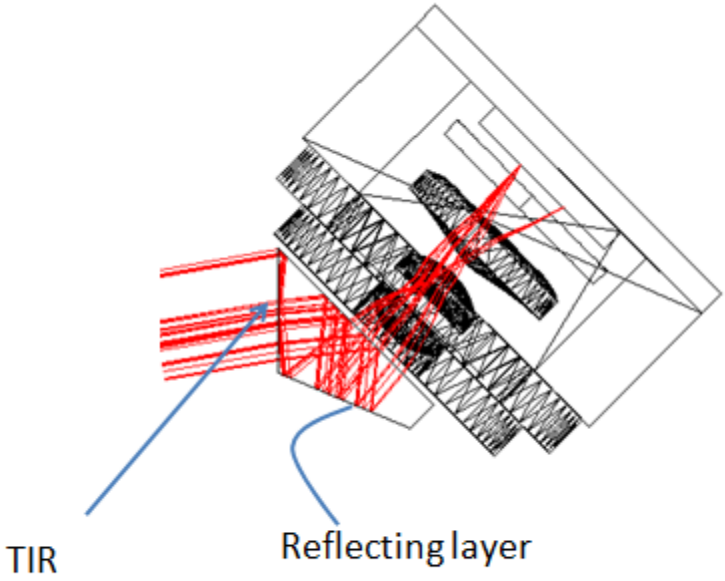


Fig. 11a: unwanted TIR reflection which produces a ghost image at the sensor.

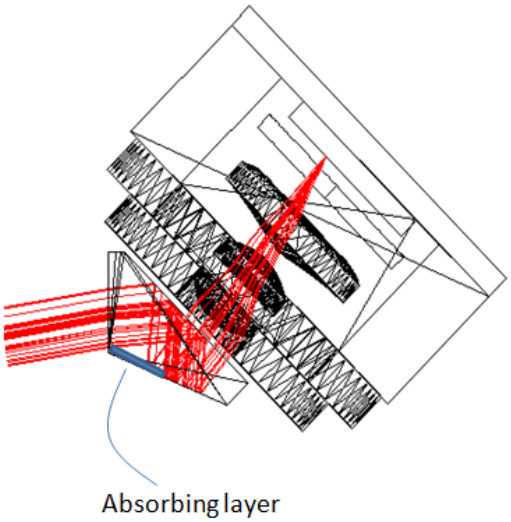


Fig. 11b: using an absorbing patch (shown in blue) to prevent the unwanted TIR reflection and removing the ghost image.

Additional features of the prisms of the first and second embodiments are means for easily placing and for removing the prisms to return the phone camera to its regular undeviated FOV.

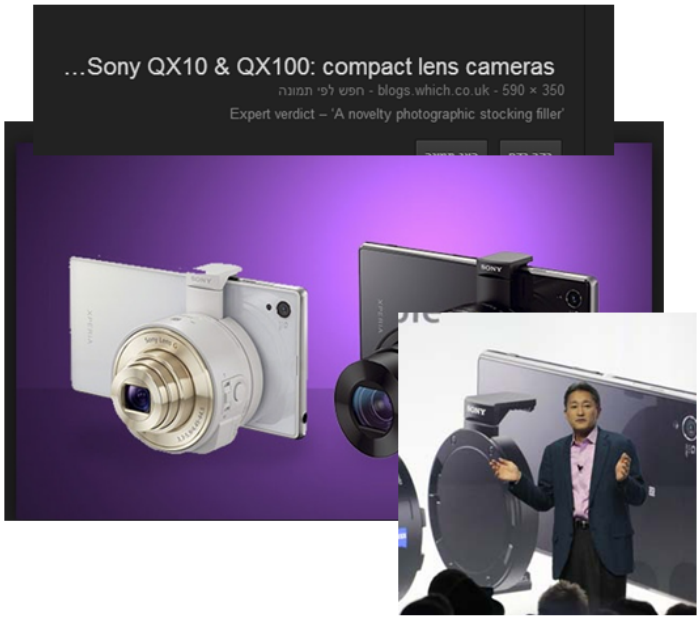
Mechanical means for mounting the prisms on a cell phone

The prior art and the market already presented some solutions or mounting optics on mobile phone cameras. Mostly they are for attachment which render the camera lens to a macro lens, telephoto lens or a wide angle lens.

These lenses are quite larger and heavier as compared with the small prisms this invention describes.

All these methods , some shown bellow for the larger lenses are also applicable to the prisms.

They mount can be a be a clip on like the Sony QX10



s

or the "Oscar" magnetic mount

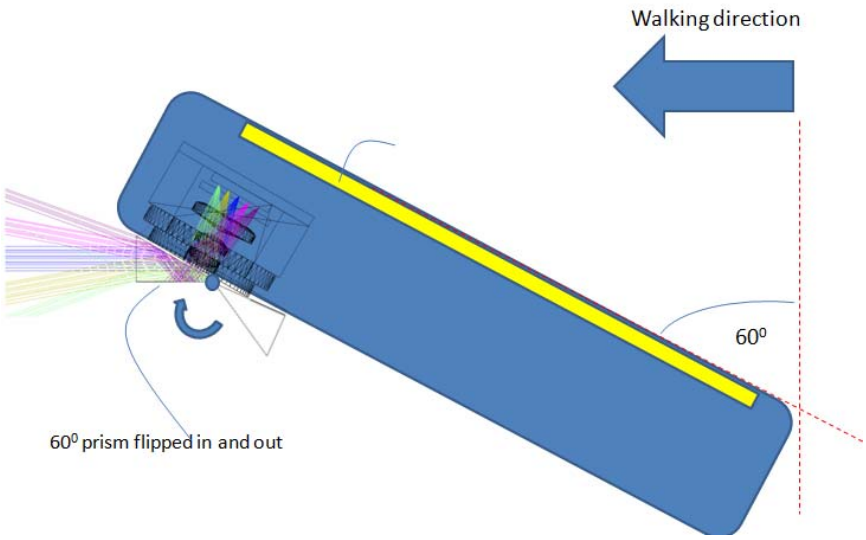
- With this lens, you can see the image with the range of 180 degrees on your phone. You can enjoy unrealistic fish-eye world of images.

Or the Olloclip corner mount

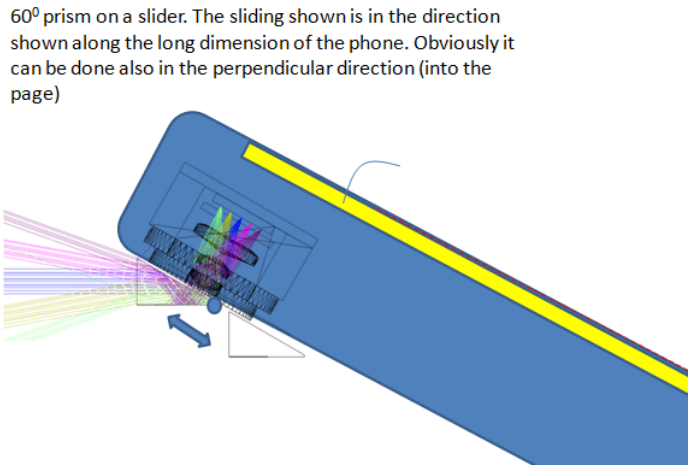
Or other ingenious and low cost solutions

In addition, due to the small size of the prisms- other solutions can be used for mounting them.

Flip up/down solution

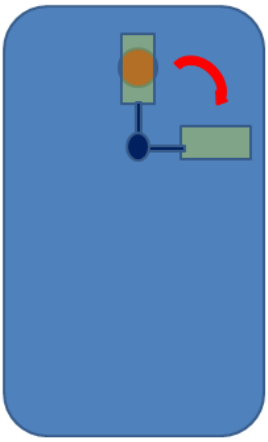


Slider solution



Swing door solution: where the prism is hinged like a small door which closes for use.

Swivel solution



Other mounting solutions:

The prisms mounting tolerances are not demanding. The prisms can also be mounted onto the phone cover and the cover thus mounted is used when the walk begins.