together, user A can transmit data (e.g., a file) to user C by looking at a device of user C (e.g., similar glasses that C is wearing, a smartphone of user C) and asking specially configured glasses (e.g., using voice, gesture) to transmit some information. The field of view may be restricted so that user B cannot receive the data unless user A is looking at B, or the field of view can be widened so that both can receive the data as long as user A is looking at both. No device pairing is needed (no user intervention on both ends for selection), and the selection of the target is made by looking at it.

[0023] While other types of communication may be used between wearable devices, there are differences in how these types of communication operate. For example, near-field communications (NFC) may be used in a similar scenario, but require devices to be in close proximity (e.g., a few cm) which may not be practical with devices such as glasses. Proximity networking (e.g., Bluetooth) may also be used, however usually requires a paring operation and selection of specific applications on both sides to perform a certain task, e.g., file transfer.

[0024] However, some features of OFC communications make them desirable in the context of wearable devices. For example, wearable devices have limited real estate on which to place transmitting devices, and so one goal of an OFC apparatus in such a case is to maximize the data transmitted from a minimum number of light emitters. In other applications where real estate is not an issue, a larger number of light emitters may be used. The light may be emitted in any wavelength, including infrared, visible, and ultraviolet.

[0025] Light emitters in the embodiments described below include light emitting diodes (LEDs), however other light emitter devices may be used, such as liquid crystal displays (LCD) and/or laser diodes. For example, future technology LCD panels may attain speeds of up to 25000 fps facilitating high speed data transfers. A single line LCD display of this type can be utilized to form a single line display. Such a display may require less space and/or power than LEDs.

[0026] Generally, OFC transmitting apparatuses described herein include an array of light emitting diodes (LEDs), at least part of which are arranged single-file along an emitting surface of the transmitting apparatus. For example, a set of LEDs may be aligned together along a single line or curve. Data is encoded and sent to the LEDs in a way that cause them to be turned on and off in a certain pattern. A receiving device (e.g., wearable device, mobile device, camera) includes a camera-type sensor that can detect and decode the data. This provides the capability to perform easy yet secure direct communication between peer devices.

[0027] An example of a data transmitting device is shown in the perspective view of FIG. **1**. This device is configured as a pair of eyeglasses **100** that may include at least some active circuitry embedded within. The circuitry includes at least an array **102** of light emitters, in this case emitter rows **102***a-b* over each eyepiece. Each of the emitter rows **102***a-b* include independently activated light emitters, such as LEDs. The rows **102***a-b* may be along a straight line, a curve, or any other path that can approximated as a one-dimensional array. The rows **102***a-b* are approximately aligned along an emitting surface **103**, which is defined here as an xy-parallel-plane. The xy-plane is at least tangent to the surface of the glasses frame where the rows **102***a-b* are attached, such that the light emitters of the rows **102***a-b* generally emit light in the z-direction, which is normal to the emitting surface **103**.

[0028] Each light emitter of the array **102** may be configured to simultaneously transmit a different part of a data signal. For example, at an instant in time, any of the light emitters that are turned on can be interpreted as transmitting a one, and the other that are turned off are transmitting a zero. For purposes of this disclosure, simultaneous transmission will be understood to encompass a range of time during which data of the array **102** is read by a receiving device. As such, some amount of delay between activation or deactivation of individual array elements may still be considered simultaneous so long as the receiving device is able to read data from the array **102** over a defined time period.

[0029] Additional emitter arrays, such as optional array **106** that includes rows **106***a-b*, may be included in a location that is complementary to emitter array **102**, e.g., at the bottom edge of each eyepiece. As will be described below, each light emitter from an upper row **102***a-b* may be synchronized with an aligned light emitter of the lower row **106***a-b*. This alignment would be along the x-axis, and light emitters aligned this way would activate or deactivate together. This would increase the field of view of the data transmitted via the arrays **102**, **106**. An increase in the number of single-file emitters in the arrays **102**, **106** will increase an amount of data that can be transmitted, as each light emitter in an array **102**, **106** can independently transmit a bit in parallel with other light emitters in the array **102**, **106**.

[0030] The emitter rows **102***a-b* also include lens assemblies **104***a-b* that emit light in free-space along the z-direction of the illustrated coordinate system. The lens assemblies **104***a-b* cause the emitted light to have a first focal length in the x-direction and a second focal length in the y-direction. For example, the lens assemblies could be configured so that the focus is at 3 m in the x-direction and at infinity in the y-direction. This may result in a large field of view in the x-direction and a small field of view in the y-direction, e.g., depending on the focus of the receiving device. For example, the smaller y-direction field of view may be obtained by focusing the receiving device in the x-direction range.

[0031] In FIG. **2**, a diagram shows how an example of a lens assembly **200** that provides differing focal lengths in the x- and y-directions according to an example embodiment. Light **203** from an array of light emitters **202** is emitted at least in the z-direction through aspherical lenses **204** and cylindrical lens **206**. In this example, a single aspherical lens **204** is provided for each of the LEDs **202**. In other embodiments, a single aspherical lens may be used to focus more than one LED. Similarly, one cylindrical lens **206** is shown, although more may be used.

[0032] The aspherical lenses **204** provide focus in the y-direction and the cylindrical lens provides focus in the x-direction. Due to the asymmetric effect of the cylindrical lens on the emitted light **203**, this results in the different focal lengths in the x- and y-directions. This will tend to "blur" the emitted light **203** in the x-direction, which facilitates viewing the light from the one-dimensional array of light emitters **202** as a two-dimensional pattern on a rolling-shutter-type optical sensor. By switching the LEDs **202** on and off at a frequency corresponding to (e.g., the same as or less than) the rolling shutter frequency, the pattern can be used to encode and transmit data.

[0033] An example of how data can be encoded on a rolling-shutter-type optical sensor is shown in the block diagram of FIG. **3**. In this example, each of an array of LEDs **302** are shown as shaded if turned off, and white if turned on. A