

How does Optical Mark Reader (aka Optical Mark Scanner) work?

Historically OMR is realized using a dedicated hardware called OMR scanner or Optical Mark Reader. OMR scanner machines have a paper tray where the paper forms are fed into. The device forwards each form towards a read head.

The electronic control unit of the scanner detects existence/non existence of marks and produces a sequence of 1's and 0's. This way the control unit obtains a matrix of digital values which will be interpreted either on the scanner or on the connected computer to produce the actual data. The scanner sends collected data to the computer (over a serial connection for example) for storing, scoring and analyzing. The scanner or the scanner software must be configured along with the form design in order to interpret the mark detection correctly.

Read-Head

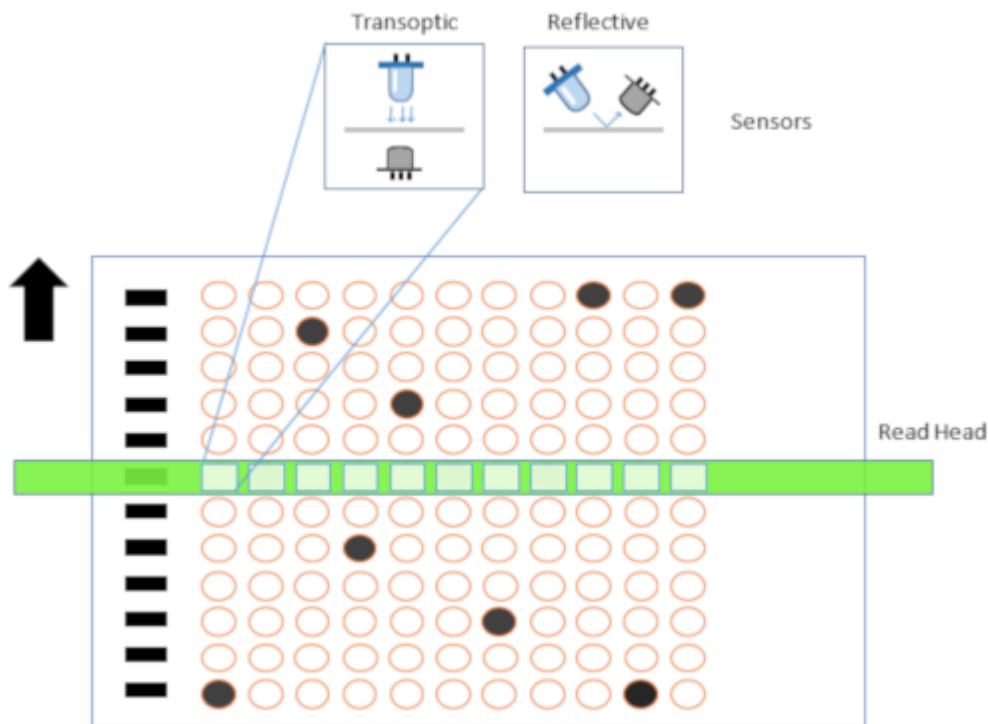
Read-head is the core of optical mark readers. There are different technologies used in OMR scanner read heads:

Conductive Mark (Mark sensing)

An older technique utilizes electrical connectivity of marked cells. If a cell is marked by a special pencil (a conductive material) a small voltage applied between the bounds will be creating a current which indicates a “marked” state. If the cell is not marked, no current will flow, which indicates a “not marked” state. This technique named “Mark Sense” does not involve light unlike the other mark detecting techniques.

Transoptic

Most frequently applied OMR technique uses a row of light emitting diode (LED) and phototransistor pairs. If the bubble in front of a LED is marked by a suitable pencil, the light will not pass the paper, otherwise the light will pass and hit on the phototransistor at the other side of the paper. The phototransistor changes its resistivity when it is exposed to light and this way detect existence of marks. This technique is called “transoptic” mark sensing.



Reflective

Another mark sensing technique also utilizes LED/phototransistor pair, but this time light is supposed to get reflected on a marked area and hit the phototransistor which is paired with the light source. If there is no mark, light is not reflected.

CIS (Contact Image Sensor)

Some optical mark readers use CIS (contact image sensor) to detect marks. CIS's are sensors that produce rows of pixels along a scan line. The scanner detects marks by counting black pixels in the mark area. If the number of black pixels exceeds a threshold, a "marked" state is detected.

Optical Forms and Markers

Different techniques have different requirements on paper thickness, colors and marking pencils allowed. Wavelength of LEDs also put some limitations on pencil type and form colors. Infrared LEDs for example, require #2 pencils, which are dark even at that wavelength.

The forms that can be read by Optical Mark Readers must satisfy some conditions. Each device specifies the weight (gr/cm^2), thickness and size of the papers that will be used as optical forms. The design of the form such as bubble diameter, thickness, colors and density, timing marks (special mark prints that indicate rows) are also specific to scanner.

- The sensors must align with the bubbles on the form so the diameter and location of bubbles must be very precise. If the papers are not cut precisely, for example, bubbles may not align with the sensors, leading to incorrect reading. Wet climate or heat may expand paper size and cause similar errors.
- The colors used in the form design should not block the light, otherwise false marks will be

- detected.
- Bubble thicknesses and labels should not be too dark.
- Depending on the technology used (wavelength of the LEDs, sensitivity of phototransistors) scanners might enforce using special markers (lead pencils for example)

Because of these strict conditions, forms for optical scanners can be obtained only from print offices or stores that produce and/or sell forms special for the device used. Software based OMR solutions (such as [MarkReader](#)) have more flexibility on the form and marker specifications. Forms can be printed and duplicated using office printers, markers of different type and color can be used. This is because image scanners produce high resolution images of paper forms, which are processed using image processing techniques to match with the form template. Bubble locations can be computed precisely despite different width and height of paper.

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