RAD

Development of the Digital Mobile X-ray System MobileDaRt Evolution™ MX9 Version

Medical Systems Division, Shimadzu Corporation
Makoto Murakami, Hiroshi Inoue, Chisa Ota, Yurina Tomohiro, Keigo Nagashima, Shintaro Nakachi, Hiroyuki Matsubara, Kazumasa Matsubara, Noboru Yamashita, Tatsuro Esaki

1. Introduction

When performing radiography with a mobile X-ray system, considerable experience for radiographers is required to ensure accurate and rapid patient positioning, as the X-ray tube and flat-panel detector (FPD) offer a high degree of positioning flexibility. Consequently, this presents issues such as longer positioning times, the possibility of unnecessary radiation exposure due to misaligned images, and inconsistent image quality.

We have developed the new mobile X-ray system, MobileDaRt Evolution MX9 Version, designed to reduce physical burden on patients and radiographers by deploying the VISION SUPPORT™ camera application. This application not only improves operational efficiency through enhanced usability and convenience but also reduces image rejects and the need for retakes. This system is available in three models based on the type of DR unit installed; in this article, we will introduce the c-type model, which is equipped with a Canon DR unit **(Figs. 1 and 2)**.

Fig. 1 MobileDaRt Evolution MX9 Version (front view)

Fig. 2 MobileDaRt Evolution MX9 Version (rear view)

2. Main Features

2.1 Second Monitor

Separate from the large touch-panel monitor (main monitor) mounted on the main unit, a small touch-panel monitor (second monitor) is mounted on the collimator **(Fig. 3)**.

With our previous models, radiographers had to operate the main monitor and X-ray control panel on the main unit to check examination information, edit exposure conditions, and review acquired images. With this second monitor, radiographers can check patient information and exam protocols, and edit exposure conditions, all during patient positioning **(Fig. 4)**. In addition, the order of protocols within the examination can be changed to suit the patient's condition. Furthermore, an acquired X-ray image can be shown on the second monitor for review at the bedside **(Fig. 5)**. These features are aimed at reducing the number of times radiographers move between the bedside and the main unit, thereby contributing to a smoother exam workflow.

2.2 Display of Collimator Angle

The collimator angle is displayed on the second monitor mounted on the collimator **(Fig. 6)**. With our previous models, radiographers positioned the X-ray tube by using the angle scales marked on the arm axis and tube axis as guides. However, these

Fig. 3 Collimator equipped with a second monitor

Fig. 4 Display of examination information and editing of exposure conditions

Fig. 5 Display of acquired images

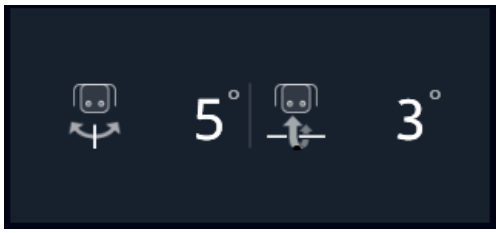

Fig. 6 Collimator angle

angle scales can be hard to see in certain positions, and when the two axes (arm axis and tube axis) are rotated simultaneously, the X-ray tube angle relative to the horizontal plane is difficult to determine. These are major factors which could cause the X-ray tube positioning to be time-consuming.

In our new system, the roll and pitch angles which are relative to the horizontal plane are shown on the second monitor with sensors inside the collimator. This makes it easier for radiographers to determine the angle of the X-ray beam and supports accurate positioning.

3. Options

The following section introduces other available optional functions aimed at improving workflow efficiency and reducing physical burden for patients.

3.1 3D Camera

The 3D camera mounted on the collimator uses image and depth information to detect the bed surface to calculate two items: the distance from the X-ray focal spot and the relative angle of the X-ray axis. These are shown on the second monitor **(Fig. 7)**. The area of the bed surface used for calculation can be manually selected by touching the area on the camera image shown on the second monitor. The surface can also be automatically selected based on the position of the patient's face. When the angle falls within a preset range, an "angle match" icon is shown beside the angle to notify radiographers. Estimated entrance surface dose is also shown on the second monitor, which is calculated based on the selected exposure conditions and the distance from the focal spot of the X-ray tube to the patient's surface.

These features support accurate positioning and appropriate exposure conditions, helping to reduce image rejects and the need for retakes. Moreover, improved positioning reproducibility reduces variations in radiographic images. This can be effective for follow-up observations during inpatient rounds and in ICUs.

Fig. 7 Measurement of distance and angle using the 3D camera

3.2 Cross Laser Marker

The Cross Laser Marker mounted on the collimator projects a cross-pattern laser light, providing a clearer indication of the center of the irradiation field, to help with accurate positioning **(Fig. 8)**. A green laser, which offers better visibility than a red laser, is used.

Furthermore, when combined with the angle-alignment notification feature from the 3D camera, the laser light can be activated when the angle between the bed surface and the X-ray tube falls within a preset range (Laser Navigation). This allows radiographers to adjust the X-ray tube to the proper angle by using the laser marker for notification while keeping their eyes on the patient's condition.

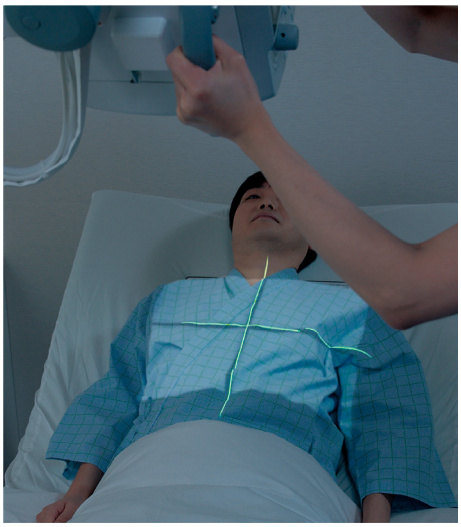

Fig. 8 Cross Laser Marker

3.3 Tube and Catheter Enhancement Image Processing (Smart Tube™)

The system features image processing that highlights (color-codes) the locations of endotracheal tubes, central venous catheters, and nasogastric tubes in chest X-ray images **(Fig. 9)**. This image processing can be executed and reviewed on the system's main monitor after the image is captured. By assisting radiographers in confirming the positions of tubes and catheters in ICUs, emergency departments, and ward rounds, this feature will contribute to patient safety.

3.4 X-ray Automatic Exposure Control (Built-in AEC Assistance: BiAA)

When CXDI-Elite is selected for the FPD, its built-in automatic exposure control function can automatically adjust the X-ray dose based on the preset pixel value. This contributes to dose reduction when using a mobile X-ray system and helps improve image quality consistency. The CXDI-Elite generates images using the elements on the X-ray image sensor surface while simultaneously detecting pixel values corresponding to the exposed X-ray. It performs automatic exposure control by detecting when the FPD's pixel values reach the reference value and stopping the X-ray in response.

Fig. 9 Tube and Catheter Enhancement Image Processing (Smart Tube™)

4. Conclusion

The MobileDaRt Evolution MX9 Version introduced here inherits the established features of previous models. It incorporates a second monitor on the collimator and offers optional functions such as a 3D camera and Cross Laser Marker.

These advancements not only significantly enhance operability and convenience but also help reduce physical burden for patients by supporting a reduction in image rejects and the need for retakes.

We expect this system to reduce the burden for both radiographers and patients while contributing to further improvements in workflow efficiency and diagnostic quality across a wide range of clinical settings, including ward rounds, operating rooms, ICUs, NICUs, and emergency departments. We will further continue to provide a better system to meet the diverse needs of the clinical field.

* The AI (artificial intelligence) technology used in Smart Tube is not a self-guided interactive learning-type AI.