Business Brief

Healthcare and Life Sciences

Visual Intelligence for Next-Generation Inpatient Monitoring Solutions

Video feeds, sensor fusion and machine learning augment next-generation inpatient monitoring and assessment solutions for improved clinical decision support.

Inpatient facilities such as hospitals and critical care centers face an imperative to address rising operating costs and staffing challenges while shifting to more value-based, patient-centric models of care delivery. Emerging digital approaches to patient monitoring can provide a needed adjunct to staff resources, systematically assessing data gathered at bedside in a minimally invasive, cost-effective manner. Frost & Sullivan findings predict growth for patient monitoring technologies at an annual rate of 4.1%, reaching approximately $23.4 billion in 2022.[1]

As machine learning and related technologies continue to advance, automated mechanisms for inpatient monitoring enhance the effectiveness of clinicians. Intel enables the ecosystem with engineering and building blocks that help accelerate time to market for high-quality, innovative inpatient monitoring solutions. The edge-to-cloud capabilities of Intel's vast hardware and software portfolio are powering the convergence of digital technologies into patient-centered instruments, devices and services.

A new generation of visual computing models enables in-room cameras — operating in and beyond the visible spectrum — to generate insights that assist human caregivers and ultimately improve the quality of care. Both algorithms and human attendants such as nurses can assess incoming streams in real time, as illustrated in Figure 1. Since patient video data is protected health information (PHI), solutions must adhere to cybersecurity best practices to meet regulatory requirements.

Improved inpatient monitoring capabilities provide greater continuity of care by assessing patient status, reducing the need for floor nurses to be occupied with extended patient observation tasks so they can focus on more urgent needs. The use of technology to reduce clinician presence for monitoring requirements can also increase the safety of caregivers by reducing their exposure to infectious patients.

Rather than relying on costly and burdensome personal protective equipment (PPE) such as gowns, gloves and masks, nurses and other providers can perform many monitoring and assessment functions without direct contact. Moreover, monitoring can be extended to remote usages, including satellite clinical facilities and at-home care, with further cost benefits and quality-of-care improvements.

Figure 1. Video intelligence for inpatient monitoring and assessment.

Data-Driven Intelligence for Patient Status Assessment

Forward-looking providers of patient monitoring solutions are seeking to expand the degree of insight that data generates about each patient. Applying deep learning algorithms to video feeds and traditional patient monitoring data can deliver a more complete patient status to clinical caregivers, as shown in Figure 2. The three aspects of visual intelligence for inpatient monitoring are discussed in the remainder of this section: data fusion, scene intelligence and digital twins.

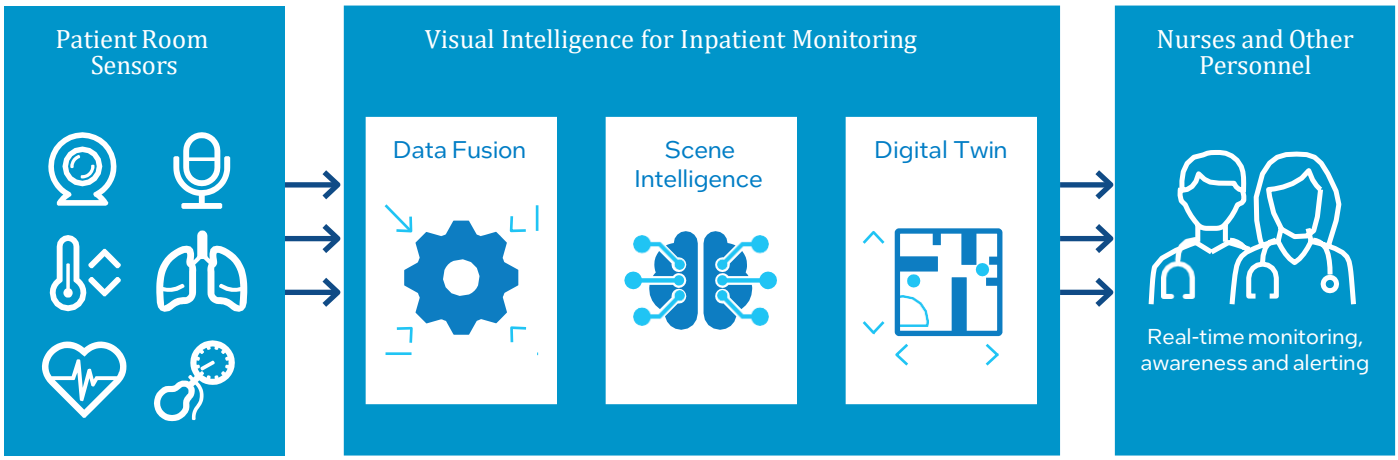

Figure 2. Enhanced visual intelligence for next-generation inpatient monitoring.

Multi-Dimensional Data Fusion

Data fusion is a critical aspect of realizing the potential of deep learning inpatient monitoring solutions. Visual intelligence complements other data feeds that are routinely captured from patient monitors, such as pulse, respiration rates, blood oxygen and temperature. These metrics can be combined with historical data, lab results, medications and other information to create a comprehensive, holistic picture of patient status. Machine logic is potentially a valuable aid to human cognition in assessing this complex, multidimensional information to produce accurate outcomes.

Drawing together these diverse datasets gathered and analyzed over periods of time can also help detect indicators of potential patient decline and alert clinical staff to act preemptively. For example, the combination of lowering blood pressure, pale and clammy skin, disorientation and poor blood profusion in hands and feet — all detectable via IP and infrared camera data analyzed in tandem — is an indication of septic shock, which needs to be addressed immediately. Taken further, this multi-modal automated monitoring approach can aid in the development of treatment plans as well as prepare the deep learning solution to anticipate specific indicators of patient recovery or setbacks.

Digitizing Reality with Scene Intelligence

Scene intelligence constructs a digital representation of physical space that supports monitoring people and objects over time. Using spatial data gathered using means such as structured light or stereo vision, the technology plots and maintains a dynamic 3D scene representation to reveal how elements interact and affect each other. Data fusion enriches each object and person in the scene, so patient monitoring solutions can provide dynamic, detailed, comprehensive insights about operations and patient care delivery.

Fine-tuning treatment regimens can help optimize patient care and the efficient use of high-value facilities assets such as emergency department and intensive care beds. The resulting cost-effectiveness can contribute directly to profitability while helping ensure availability of resources for the patients who need them most.

Potential for Data-Rich Virtual Modeling with Digital Twins

Digital twins are software-based models of physical objects that represent changing states over time, responding to changes in the environment as shown in Figure 3. Originally developed for industrial facilities and equipment, the concept can be applied to an organ or system within a patient's body, the whole patient, a room or even an entire facility.

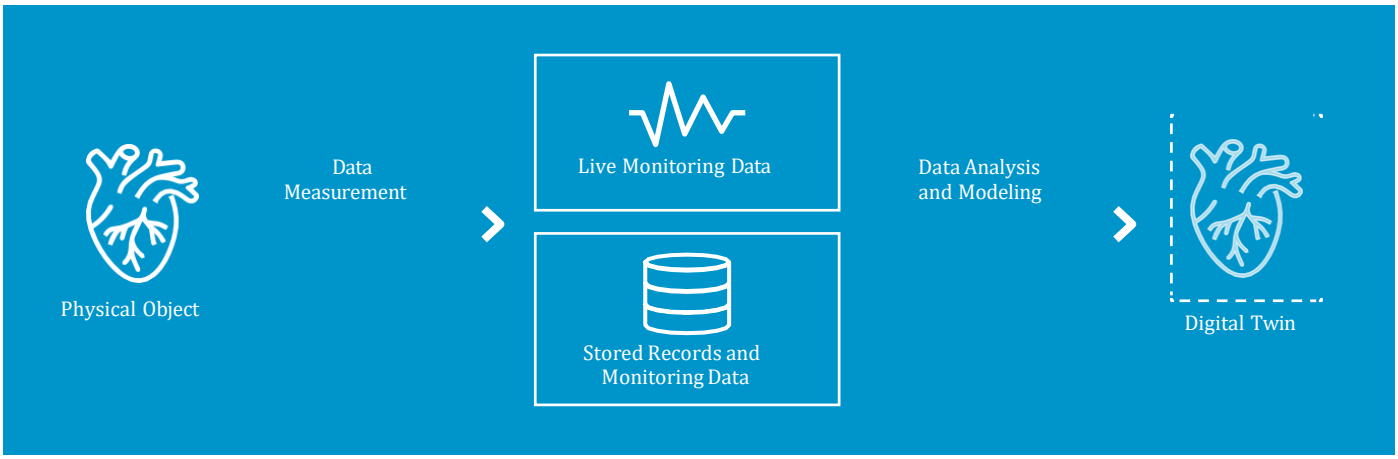

Figure 3. Digital twin of physical object, powered by live and historical data.

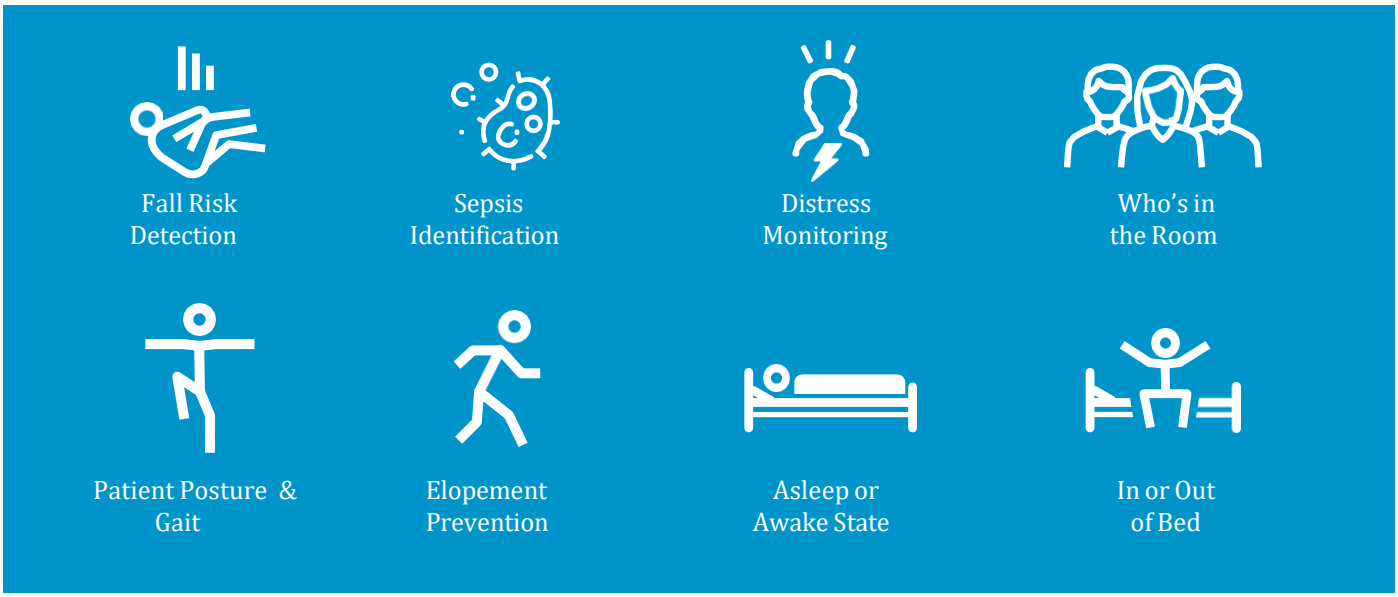

Figure 4. Inpatient visual monitoring insights.

Combining medical records data with ongoing care and medication details and monitoring data can provide a comprehensive, evolving representation of the patient. Applying deep learning algorithms against the data in this representation can predict likely outcomes from various diagnostic and treatment decisions. The resulting data-driven decision-making has potential to improve the quality of care and patient health outcomes.

Improved Efficiencies and Patient Outcomes

Inpatient healthcare is traditionally resource-intensive, with a high standard of care requiring continual direct contact between clinical staff and patients. Furthermore, multiple factors constantly compete for the attention of nurses and other floor personnel, which can make it challenging for them to systematically gather optimal levels of patient information and initiate care protocols accordingly. While fully anticipating and responding to patient needs requires the experience and intuition of human caregivers, useful insights about many aspects of care can be generated by complementary technologies; some examples are shown in Figure 4.

Collecting a wide range of objective and subjective measures of patient status can provide high-quality inputs to support clinical assessments. For example, data can be used to quantify critical factors such as sleep/wake cycles or the frequency and duration of seizures. It could also be adapted to assess information using standard tools such as the Glasgow Coma Scale, Sequential Organ Failure Assessment (SOFA) and Memorial Symptom Assessment Scale. Metrics can be captured and appended to the patient's electronic health record in draft form to be quickly approved by a clinician, efficiently and quickly making critical data available for future treatment decisions.

In addition to providing better outcomes for patients, safety improvements offered by enhanced monitoring are directly associated with cost savings for providers. The expense associated with a patient fall can easily reach $15,000 to $30,000, and the average 500-bed hospital experiences as many as 50 falls each month.[2] This factor alone can lead to unnecessary expenses of millions of dollars per year. Preliminary research suggests that automated video monitoring has the potential to reduce unattended bed exits, helping to prevent fall-related injuries.[3]

Next-generation patient monitoring could include a "talkback" function that enables clinical caregivers to check in with patients from outside the room when warranted, potentially including virtual rounding by attending physicians. Likewise, chatbots hold future potential to extend and augment assessments by automating interactions with patients. These types of communication could be particularly valuable for investigating neurological status by assessing lucidity and pain.

Chatbots could have the added capability to communicate with patients in a range of native languages. Automated attendants could check in on patients periodically on matters of concern, providing increased bed coverage at a given staff level. They can draw information conversationally from patients, such as needs for additional medication or other assistance that might not be volunteered without prompting. Integration with visual intelligence systems can inform these mechanisms with refinements such as not interrupting discussions in patient rooms or speaking to patients while they are asleep.

Digital monitoring and automated data collection provides patient insights that assist nurses and other clinicians. They reduce the need for floor nurses and others to be occupied with extended patient observation. At the same time, machine-driven assessments may be more consistent than those performed by human clinicians, which tend to vary with personnel changes and over time. This combination of factors can help hospitals and other clinical facilities deliver better care at lower cost.

Conclusion

Future inpatient monitoring systems are poised to help hospitals and other clinical facilities provide better support for human caregivers while also improving patient experience and outcomes. Applying deep learning algorithms to in-room video feeds can yield a range of insights about patients that enable data-driven clinical decision making. This approach can also improve patient safety against risks such as falls and elopement, protecting patients and reducing financial exposure for providers.

Intel works with the provider ecosystem to bring innovative inpatient monitoring solutions to market. Deep expertise and sophisticated hardware and software building blocks are helping the industry conceive the future of patient experiences and outcomes. Building new capabilities for optimizing the efficiency and quality of patient care, these solutions have the potential to improve patient and business outcomes simultaneously.

Data generated by computer vision and video analytics can be combined with other sources to provide a holistic view of a patient's state. These spatiotemporal maps are the basis for a thrust of innovation that includes digital twins, which respond to real and experimental inputs to help capture and predict changes over time. Looking ahead, solution providers are applying cutting-edge computer science to patient monitoring data and workloads, helping define the future of cost-effective, personalized, technology-driven care.

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[2] Modern Healthcare, August 31 2021. "Protecting patients with live video monitoring and analytics." https://www.modernhealthcare.com/technology/protecting-patients-live-video-monitoring-and-analytics.

[3] Journal of Patient Safety, December 1 2021. "Evaluation of Automated Video Monitoring to Decrease the Risk of Unattended Bed Exits in Small Rural Hospitals." https://pubmed.ncbi.nlm.nih.gov/33009181/.

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