

FDA Cleared | CE Marked | Clinically Proven | Enterprise Wide

**17** Improved  
Nodule  
Detection<sup>1</sup>

Enterprise-wide capability powered by acquisition normalization technology that allows “plug in” ability across all manufacturers and diverse imaging protocols.

High throughput, scalable computation on off-the-shelf hardware and virtual machine deployments.

No additional radiation dose or changes to existing imaging protocols are required.

Reduces the burden of visual search and assessment.

Automatically inserts the images into the patient’s file for instant access.

**19** Faster  
Reads<sup>1</sup>



**Riverain**<sup>TM</sup>  
TECHNOLOGIES

<sup>1</sup> Lo, S. B., Freedman, M. T., Gillis, L. B., White, C. S., & Mun, S. K. (2018). JOURNAL CLUB: Computer-Aided Detection of Lung Nodules on CT With a Computerized Pulmonary Vessel Suppressed Function. *American Journal of Roentgenology*, 210(3), 480–488. doi: 10.2214/ajr.17.18718.



The Riverain Technologies™ ClearRead™ Xray platform is comprised of four FDA-cleared applications designed to improve reading efficiency and accuracy across the hospital enterprise without requiring additional hardware. The solutions optimize the diagnostic value of all portable and upright images.

## Bone Suppress

ClearRead Xray Bone Suppress increases the visibility of soft tissue in standard chest Xrays by suppressing the bone on the digital image without the need for two exposures. The bone-suppressed image helps radiologists to detect 1 out of 6 previously missed nodules.<sup>1</sup>



## Detect

ClearRead Xray Detect identifies regions of interest that warrant further examination. The software can detect 1 in 2 previously missed nodules<sup>2</sup> allowing identification of lung cancer up to 18 months sooner.<sup>3</sup>



**“Certainly in our practice we absolutely have had proven cancers where, when we were reading the study, we did not see them until we looked at the bone-suppressed image.”**

Peter Sachs, MD  
University of Colorado Hospital

1 Freedman, M. T., Lo, S.-C. B., Seibel, J. C., & Bromley, C. M. (2011). Lung Nodules: Improved Detection with Software That Suppresses the Rib and Clavicle on Chest Radiographs. *Radiology*, 260(1), 265–273. doi: 10.1148/radiol.11100153

2 Chen, J. and White, C. (2008). Use of CAD to Evaluate Lung Cancer on Chest Radiography. *Journal of Thoracic Imaging*, 23:93–96.

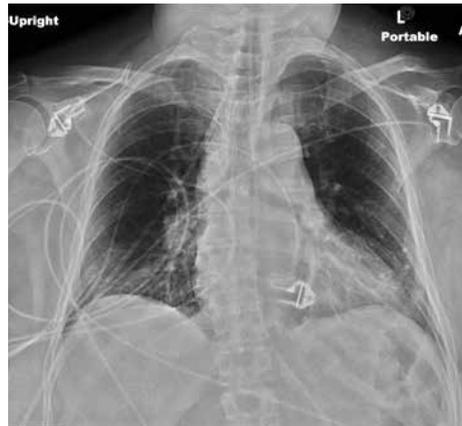
3 Gilkeson, Robert C. and Frolkis, Calen. Performance of a Next Generation Computer-Aided Detection Algorithm for the detection of overlooked lung cancers on Chest Radiographs. RSNA, 2013.

## Confirm

ClearRead Xray Confirm optimizes and standardizes portable chest Xrays and improves the conspicuity of lines and tubes without compromising diagnostic image quality. The application minimizes or eliminates the need for image adjustments, reducing reading time by 19-35%.<sup>1,2</sup>



Original



ClearRead Xray | Enhanced



ClearRead Xray | Confirm

1 Riverain Technologies ClearRead +Confirm FDA 510(k) Reader Study Results, 2012.

2 White, Charles. Verbal quotation of site findings. University of Maryland Medical Center, MD. 27 August 2012.

## Enterprise deployment of ClearRead Bone Suppression and Confirm: University of Colorado



UCHealth expanded their use of Riverain Technologies ClearRead Xray Bone Suppress and ClearRead Xray Confirm software to all five of their

flagship hospitals in October 2016 after five years of clinical use at the main campus hospital, Anschutz Medical Campus in Aurora.

UCHealth is a nationally recognized system of five hospitals and more than 100 clinics, including University of Colorado Hospital, Poudre Valley Hospital, Medical Center of the Rockies, Memorial Hospital Central, and Memorial Hospital North.

ClearRead Xray Bone Suppress forms a soft tissue image by subtracting the ribs and clavicles from the standard chest x-ray, allowing radiologists to more effectively detect focal densities. Powered by cutting-edge machine learning, it is the only software product to perform robust, pixel-level bone suppression throughout the entire body.

ClearRead Xray Confirm optimizes the visual quality of chest x-rays, including improving the conspicuity of lines and tubes on portable images, allowing radiologists to read up to 19% faster.<sup>3</sup>

The software immediately enhances any adult chest X-ray image after capture from upright or portable imaging machines, without the need for additional imaging equipment. It seamlessly integrates into any digital radiology department, offering universal connectivity with existing PACS, and can be used to improve the visibility and detection rates of focal densities, including nodules.

ClearRead Bone Suppress is a software solution, so it can easily be applied to every X-ray device in the facility for one fixed cost.

3 Lo, S. B., Freedman, M. T., Gillis, L. B., White, C. S., & Mun, S. K. (2018). JOURNAL CLUB: Computer-Aided Detection of Lung Nodules on CT With a Computerized Pulmonary Vessel Suppressed Function. *American Journal of Roentgenology*, 210(3), 480–488. doi: 10.2214/ajr.17.18718.

# Compare

ClearRead Xray Compare aids in the detection of soft tissue interval changes across current and prior chest Xrays by registering the bone-suppressed images and creating a difference image. The software allows detection of 1 in 10 previously missed emerging nodules.<sup>1</sup>



Current Xray



Prior Xray



ClearRead Xray | Bone Suppress  
(Current)



ClearRead Xray | Bone Suppress  
(Warped Prior)

Register and Subtract  
(Prior-Current)

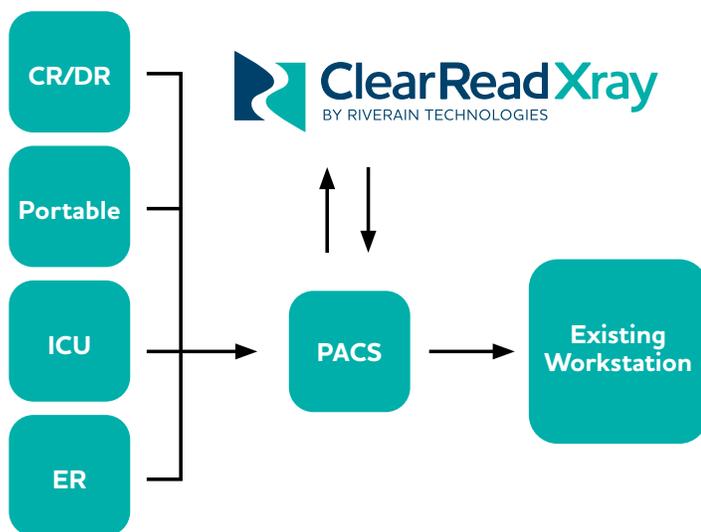


<sup>1</sup> Riverain Medical DeltaView FDA 510(K) Reader Study Results 2011.

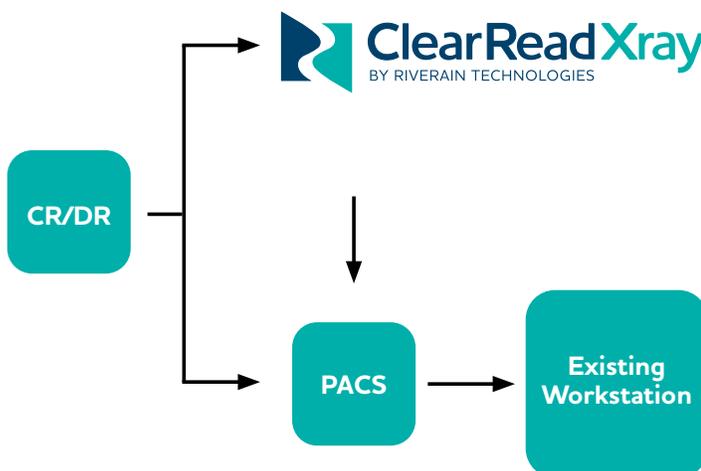
## Installation and Workflow

Acquisition normalization technology, along with programmable routing and exam filtering tools, allows rapid installation and site-specific configuration. ClearRead™ applications produce adjunctive DICOM images and content that seamlessly interface with the existing facility PACS. The result is a cost-effective, efficient viewing experience for the radiologist.

## Enterprise PACS Push Workflow



## Modality Dual Push Workflow



## Host Machine Specifications

### Minimum server specifications:

- Intel Xeon E3-1230 v5
- 8 GB RAM
- 100 GB disk (dedicated storage)
- 1 Gbit/sec Ethernet controller

### Minimum virtual specifications:

- 4 vCPU with 14 GHz CPU reservation
- 8 GB RAM reservation
- 100 GB disk
- 1 Gbit/sec Ethernet controller

### Operating System:

- Windows 7 Professional/Enterprise/Ultimate 64-bit
- Windows 8.1 and Windows 10 Professional/Enterprise 64-bit
- Windows 2008 R2 Server 64-bit
- Windows 2012 R2 Server 64-bit
- Windows 2016 R2 Server 64-bit
- Windows 2019 Server 64-bit

### Web Browser:

Microsoft Internet Explorer 10 or better, with cookies and Javascript enabled.

### Software Protection Key:

The HASP-HL key requires:

- One USB Type A port available
- Power consumption 50mA operating/ <0.5mA standby

### Third Party Software:

Riverain recommends against installing ClearRead Xray on a multi-use instance of a VM or having multiple roles for a physical server by adding additional third-party software.

**“It’s easy to install. It’s easy to train to. And frankly, it provides immediate clinical value.”**

- Ella Kazerooni, MD  
University of Michigan Health System

**29** Fewer Missed Nodules<sup>1</sup>

**26** Faster Reads<sup>1</sup>

Enterprise-wide capability, processing scans from all CT manufacturers and acquisition protocols.

High throughput, scalable computation using off-the-shelf hardware with virtual machine deployments.

Supports contrast and non-contrast scans.

Supports standard, low-dose, non-contrast and contrast CT scans.

Automatically detects nodules at or above 5mm and supports visualization of nodules smaller than 5mm.

Detects all nodule types: solid, part-solid, and ground-glass.

Provides differential measurements.

<sup>1</sup> Lo, S. B., Freedman, M. T., Gillis, L. B., White, C. S., & Mun, S. K. (2018). JOURNAL CLUB: Computer-Aided Detection of Lung Nodules on CT With a Computerized Pulmonary Vessel Suppressed Function. *American Journal of Roentgenology*, 210(3), 480–488. doi: 10.2214/ajr.17.18718.

ClearRead CT is the first FDA-cleared device to support concurrent reading, allowing for faster reading with proven superior automatic nodule detection performance for all nodule types, including solid, subsolid and ground glass nodules.

## Vessel Suppress

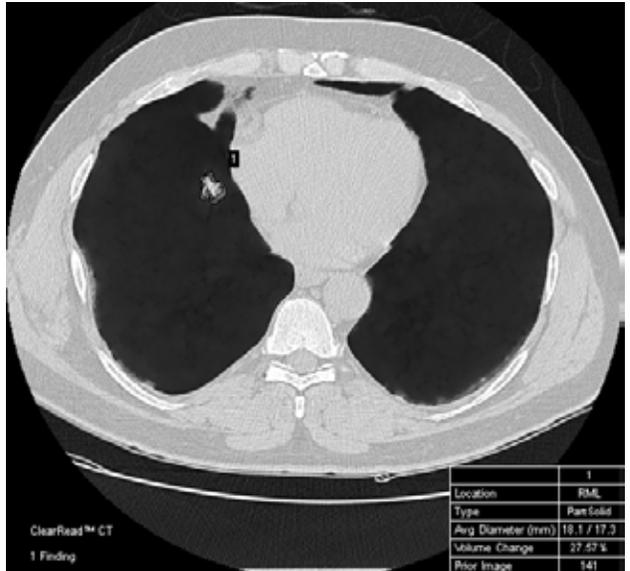
ClearRead CT Vessel Suppress produces a secondary series, suppressing vessels and other normal structures within the lungs to improve nodule conspicuity as shown in the image to the right. The Vessel Suppress series gives users access to a truly unique and patented technology that aids in improving reading accuracy and efficiency. The processed series can even be easily linked with the original CT series for synchronized scrolling.

Vessel Suppress not only enables improved nodule detection by eliminating obscuring normal structures, it also allows improved nodule characterizations for all nodule types. Improved characterization derives in part from the ability for precise segmentation of nodule boundaries. Aside from volumetrics, the Vessel Suppress series enables a unique view of nodules.

## Detect

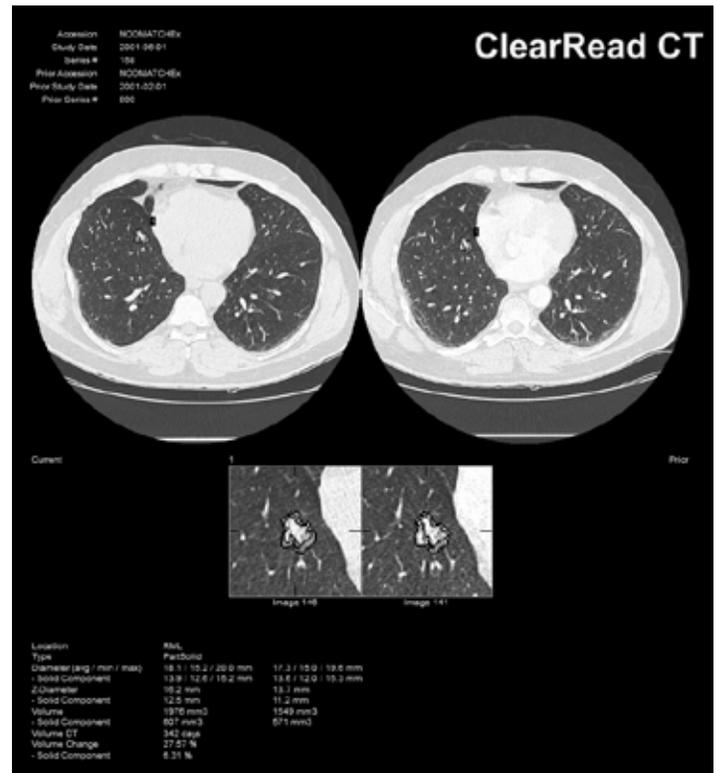
ClearRead CT Detect leverages the vessel-suppression series to locate and characterize suspected nodules, enabling transparent, precise automatic measurements. The image to the right shows the detection and characterization of a ground-glass nodule.

Detect provides measurements related to each detected region of interest including: location, type, volume, maximum, minimum, and average axial plane diameters, depth, and average density in Hounsfield units.



## Compare

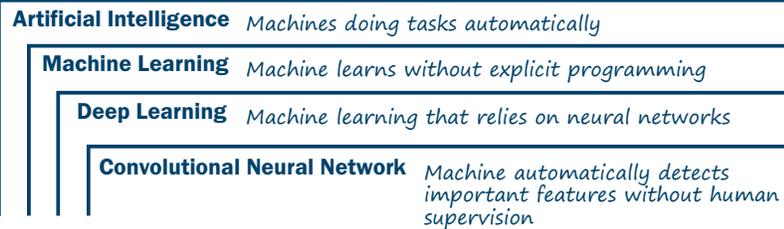
ClearRead CT Compare extends Detect by automatically matching nodules found in a current exam to the same nodule in a prior exam, enabling efficient visual and volumetric comparisons. The image to the right includes the current exam on the left and the prior exam on the right. The image chips at the bottom provide a close-up view of the individual finding, along with extracted measurements.



## Unique Technology for Computer Assisted Reading

### Reliable Deep Computation Using Machine Learning

ClearRead is a modern approach utilizing the latest advances in machine learning, such as deep learning. ClearRead has surpassed the state-of-the-art by a significant margin based on a combination of frameworks, modeling, and computational ingenuity.



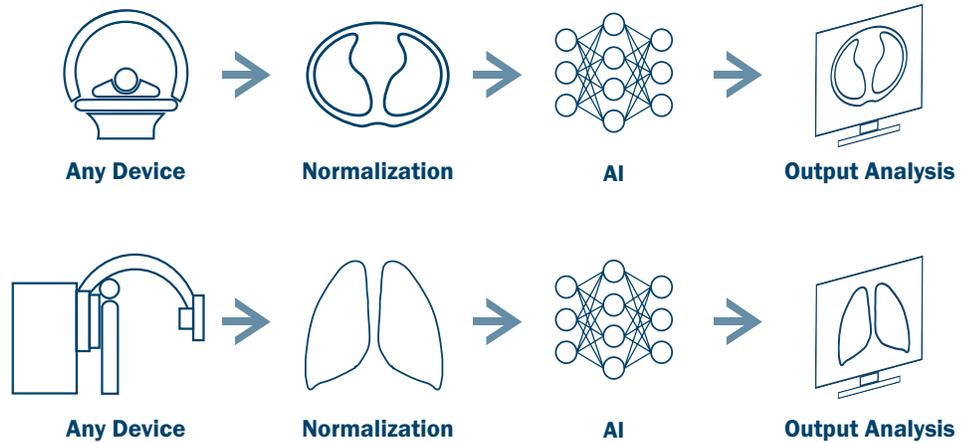
## Acquisition Independence

ClearRead handles a broad range of acquisition protocols, a difficult problem for automatic analysis algorithms. Riverain Technologies developed adaptive algorithms, so each scan is normalized for factors such as:

- Noise
- Reconstruction kernels
- Slice sampling effects

Conventional approaches collect data from different sensors to adjust component algorithms. This leaves them vulnerable to changes in hardware, protocols, and reconstruction methods.

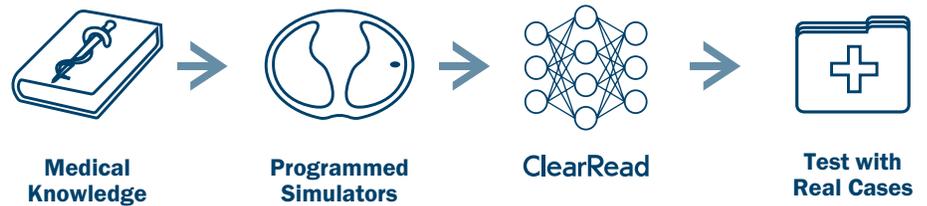
Our adaptive process allows our software to be vendor neutral. ClearRead provides enterprise imaging without compromise, while also enabling fast and simple installation.



## The Riverain Technologies Difference

The standard approach to building large, complex models requires large measured training sets. These high-quality medical data sets are both time consuming and expensive, to collect. Many cases look similar, and do not include rare cases.

Riverain developed the capability to create synthetic nodules automatically and place them into relevant anatomical contexts – such as next to the pleura wall or attached to a vessel. ClearRead was built on thousands of simulated, diverse nodules. By doing this, our software has been trained on more complete cases (including more rare cases), and tested on full training sets.



**Standard Approach**  
90% of cases are used to build the model



**Our Approach**  
Using simulated data allows cases to be used for testing



## Improving Accuracy and Efficiency for Clinicians

ClearRead aims to aid the more arduous medical interpretation tasks, including a systematic, thorough investigation of each voxel so that radiologists can focus on actual clinical decision making and improving their patients' lives.