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DIGITAL INNOVATION

Bone Suppression

AI for Chest X-Rays

Bone Suppression:
AI for Chest X-Rays

With the ***Bone Suppression*** algorithm, an algorithm based on artificial intelligence (AI) is applied to a standard chest X-ray taken in a single exposure to automatically remove the bone structures. The result is a high-quality output image that facilitates the visibility of soft tissues without needing to expose the patient to additional doses of radiation.

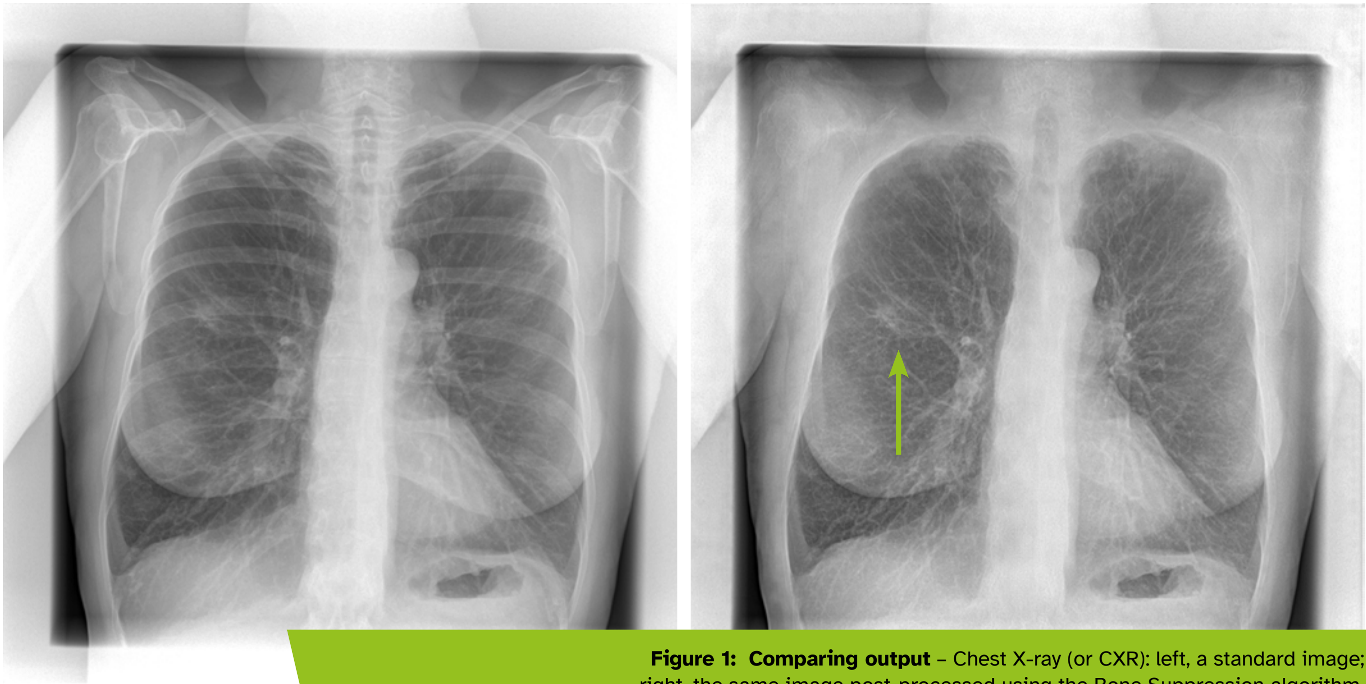


Figure 1: Comparing output – Chest X-ray (or CXR): left, a standard image; right, the same image post-processed using the Bone Suppression algorithm.

Abstract

The high portability, the degree of standardisation, the simple and quick execution, the reduced radiation doses administered to patients, the limited costs, and the general workflow efficiency have contributed to the wide use of **chest X-rays**, so that they are now a **standard exam** used to diagnose **pulmonary diseases and conditions**.

From both technical and clinical points of view, however, **interpreting chest X-rays may be complicated. Bone structures** with high contrast (ribs and clavicle) may **obscure** all or part of the **pulmonary lesions** and therefore lead to **errors** if not even **missed diagnoses. This is why it is still worth developing effective methods to support technicians and doctors** in identifying pulmonary pathologies.

The Bone Suppression (BS) algorithm is a tool that creates an X-ray image with better visibility of the pulmonary field by reducing the noise caused by bone structures.

This technology has three main strengths:

- it uses standard X-ray images;
- there is no need for any special additional equipment;
- there is no need to expose the patient to additional doses of radiation.

Features and Operation

Background and Potential

Chest X-rays are useful for assessing the airways, lungs, pulmonary veins, mediastinum, heart, pleura, and chest wall.

This routine practice typically involves a **posteri-or-anterior projection** (PA) and a **left lateral view** (LAT) taken with the patient in an upright position. In certain clinical situations — for example, patients in intensive care, bedbedridden or post-op patients — the use of **portable X-ray systems** is necessary. In this case, anterior-posterior (AP) projections are common.
The **limits of this technique** lie in the fact that although a large amount of information is collected, **two-dimensional X-ray projection** implies that **soft tissue and bone tissue overlap** in a single image, which may generate **output that is difficult to interpret** in certain situations.

The potential lesions being investigated appear as changes in contrast (shades of grey) with respect to a standard image free offrom disorders. However, such **contrasts** may be **reduced or even obscured** by the signal generated by **bone tissue**, making the image more problematic to interpret.

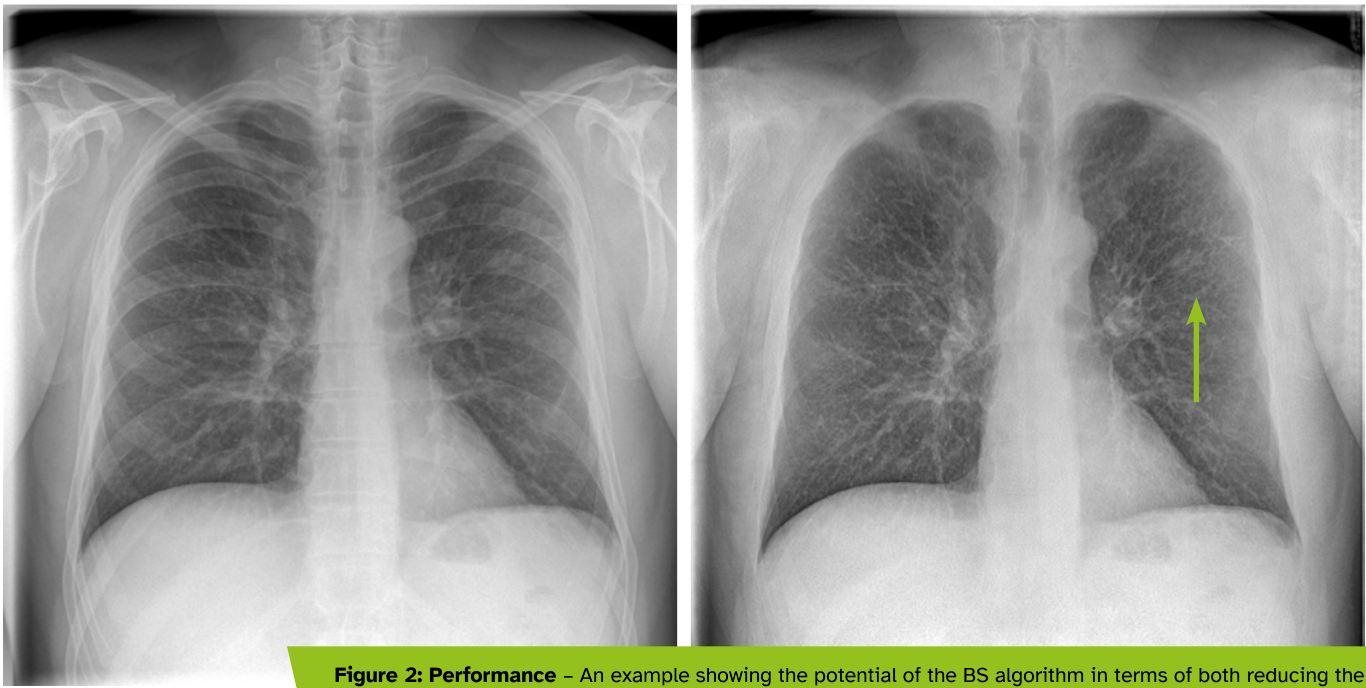


Figure 2: Performance – An example showing the potential of the BS algorithm in terms of both reducing the noise generated by bone tissue and rendering the grey tones relating to the presence of possible lesions.

Bone Suppression (BS) is a **post-processing algorithm** that compensates for the limits described above. It **removes the bone component from a standard chest X-ray image** (PA or AP), increasing the **visibil-ity of soft tissues** and therefore any **possible lesions**.

Image Generation Using the Algorithm

The BS image results from a **RAW image** processed using an **AI algorithm** that relies on a ***deep convolutional neural network (DCNN)***.

The BS algorithm was trained on a **dataset of images with and without pathologies, equally distributed between men and women** and based on an initial sample of adult individuals **of different ages** (19–98 years).

The **actual training dataset** was integrated with **augmented data** to expand the **representativeness of the dataset** to better approximate variabilities in the **entire population**.

Management Flow

How does BS work? Starting with a **RAW image**, the algorithm subtracts the bone parts and generates an **additional image — in RAW format** — to use for the desired post-processing.

In addition, using proprietary Digitec software, following acquisition the algorithm applies **automatic post-processing** (ATH filters, LUT curves, recognition of collimated areas) to the image, guaranteeing **high-quality output**[1].

If the doctor considers it useful for diagnostic purposes, **the usual manual post-processing procedures** (filters, text insertion, measurements, enlargements, etc.) can be applied to the resulting BS image.

The **strength** of this workflow lies in the fact that with the **RAW format**, the most suitable post-processing can be applied, **regardless of variabilities relating to the various types and levels of post-processing** which depend on the desired objective. (This becomes particularly challenging with images *for presentation*, that is, those that are fully post-processed.)

[1] If the algorithm is purchased as a separate DLL module, the DLL must necessarily receive the image in RAW format. All BS output images in RAW format must be post-processed to optimise visualisation of the image. It should be noted that the DLL also works without a GPU.

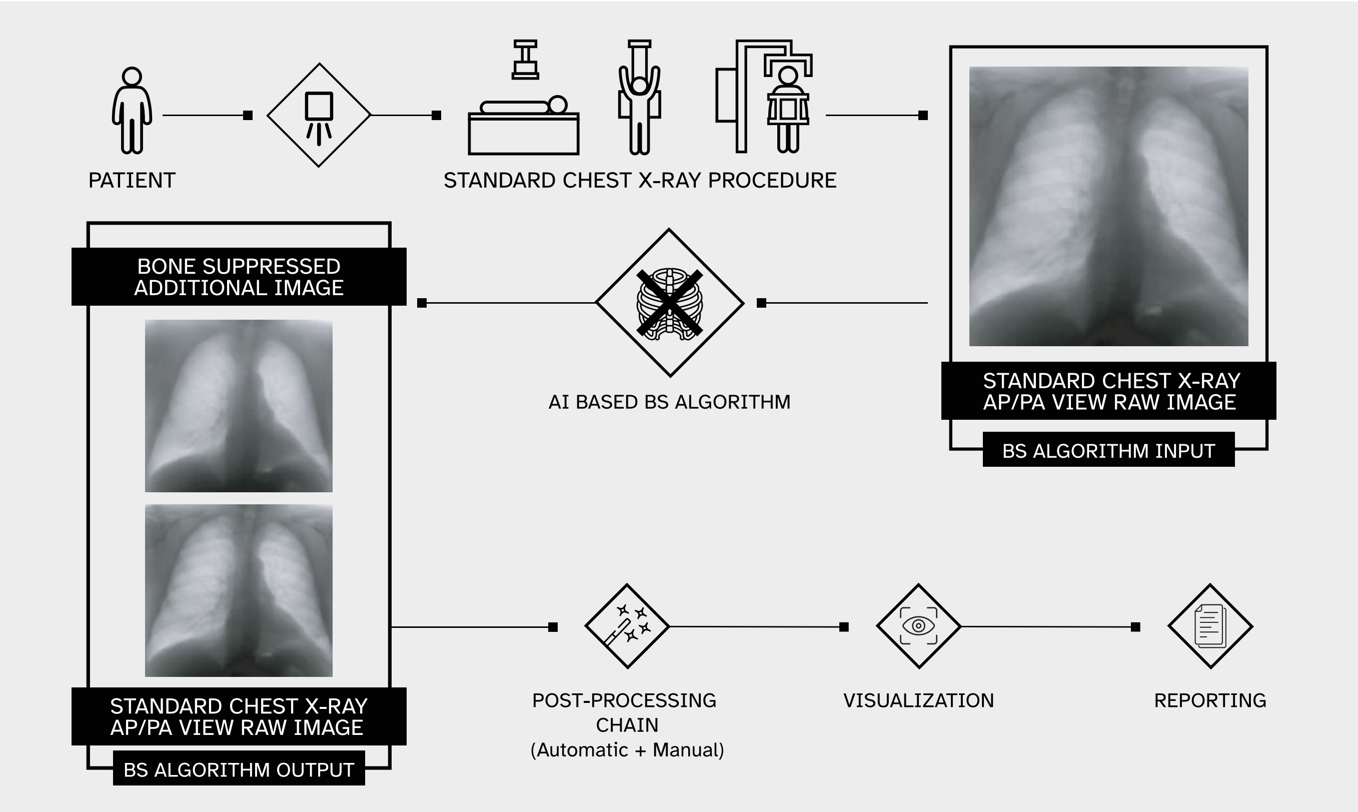


Figure 3: The workflow – The BS algorithm uses the original RAW image to generate an additional image in RAW format, but with the bone component removed. The algorithm does not weigh down or slow down the system, require additional acquisitions, or involve increased doses of radiation administered to the patient. Any common manual post-processing deemed necessary for visualisation and reporting can be applied to this image, which is used in addition to (rather than replacing) the standard projection.

Flexible, Powerful, Safe

The BS algorithm therefore:

- Can be integrated into the normal workflow **without weighing it down**
- Provides an **additional image** with the **bone components removed**
- Does not require additional acquisitions, **avoiding increases in the radiation dose** administered **to the patient**

Note: With respect to the underlying standard projection, the BS image is an **additional image** and ***not*** a **replacement**. It should be assessed by the doctor together with the standard image. In the **DICOM flow** (for example, during transmission to PACS), it should also be associated with the standard image.

Bone Suppression vs Dual Energy

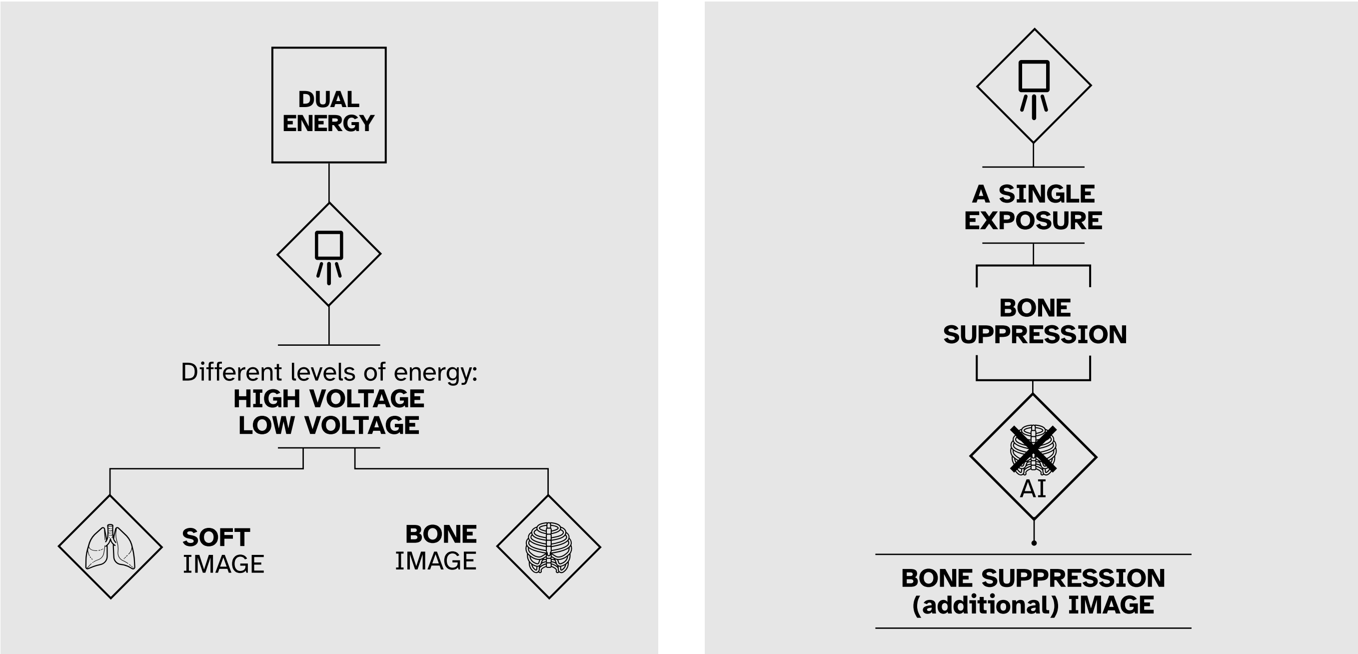
Comparing Technologies

DUAL ENERGY (DE)

The DE algorithm is used to separate soft tissues from hard tissues by acquiring ***two different* images** at different energies and then deleting the bone tissue by taking the difference between the acquired images.

BONE SUPPRESSION (BS)

The BS algorithm is designed to obtain a similar result — the removal of bone tissue — using software to process ***a single* image**. A BS image is therefore similar to the 'soft' image obtained using the DE technique.



Figures 4 and 5: A comparison of the BS and DE workflows

- With regard to diagnostic approach, **DE** performs **a physical separation of the tissues**, generating a dedicated 'bone' image[2].
- In contrast, **BS does not require complex (and generally costly) systems** to make two exposures at different energies, since no exposures other than the standard exposure are necessary.
- Last but not least, the **BS technique does not involve any increased doses of radiation** for the patient because only a single exposure is made. It also generates **images free** of characteristic **movement artefacts**, which DE images are inherently subject to.

Which technique should be used?

The comparison between BS and DE confirms that **no technique is better** than the other. The choice to use BS or DE should be made depending on the **specific pathology being investigated**.

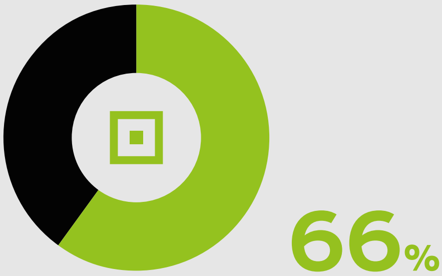
In addition, the most effective technique should **always be chosen based on the patient's clinical background**.

[2] In certain conditions, DE may provide other information about ongoing processes (for example, when examining the calcification of a nodule: if it is visible in the 'bone' image, the nodule has a calcified part which would then be treated accordingly.

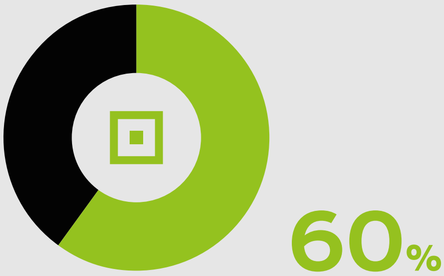
Confidence: Statistics

In a preliminary study conducted on a **sample of 40 images** with and without pathologies, the BS algorithm was submitted to the opinion of radiological experts. They used ***visual grading analysis*** (VGA) to assess the effectiveness of *Bone Suppression* in removing the bone structures and improving the visibility of soft structures, without assessments relating to the clinical impact of possible pathologies on the diagnosis.

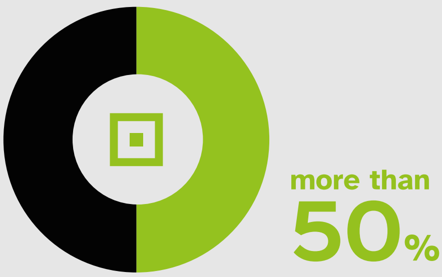
Given that the BS functionality produces an **additional image** that should **always** be used **in support of the standard image** (rather than replacing it), and that the VGA procedure respected this requirement, the results show that in the BS images examined:



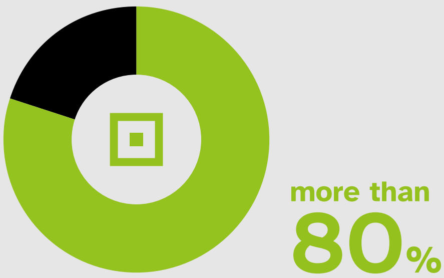
In two thirds of cases, removal of the bone component was considered **satisfactory** (the visibility of soft tissues decreased in less than 10% of cases).



There was **significant improvement** in the **visibility of soft tissues in** about **60% of cases**.



In more than 50% of all **cases** examined, there was **improved visibility of the soft tissues overlapping bone tissues** compared to the original image**.**



Finally, in **more than 80% of cases**, the image processed with the BS algorithm showed **'no presence' or 'little presence' of artefacts** that could alter the perception (compared to the original image) of soft tissues not overlapping bone tissues.

Conclusion

As with all algorithms developed by Digitec, **BS** was also designed as a **tool to support, simplify and enhance the work of technicians and doctors**. In fact, Digitec aims to use software and artificial intelligence for tasks that can be done by a machine, allowing medical workers and doctors to dedicate themselves to the **human aspect that no software can ever replace**: attention to patient care.

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