

GDXray: The database of X-ray images for nondestructive testing

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Abstract In this paper, we present a new dataset consisting of 19,407 X-ray images. The images are organized in a public database called GDXray that can be used free of charge, but for research and educational purposes only. The database includes five groups of X-ray images: castings, welds, baggage, natural objects and settings. Each group has several series, and each series several X-ray images. Most of the series are annotated or labeled. In such cases, the coordinates of the bounding boxes of the objects of interest or the labels of the images are available in standard text files. The size of GDXray is 3.5 GB and it can be downloaded from our website. We believe that GDXray represents a relevant contribution to the X-ray testing community. On the one hand, students, researchers and engineers can use these X-ray images to develop, test and evaluate image analysis and computer vision algorithms without purchasing expensive X-ray equipment. On the other hand, these images can be used as a benchmark in order to test and compare the performance of different approaches on the same data. Moreover, the database can be used in the training programs of human inspectors.

Keywords X-ray testing · datasets · X-ray images · computer vision · image analysis.

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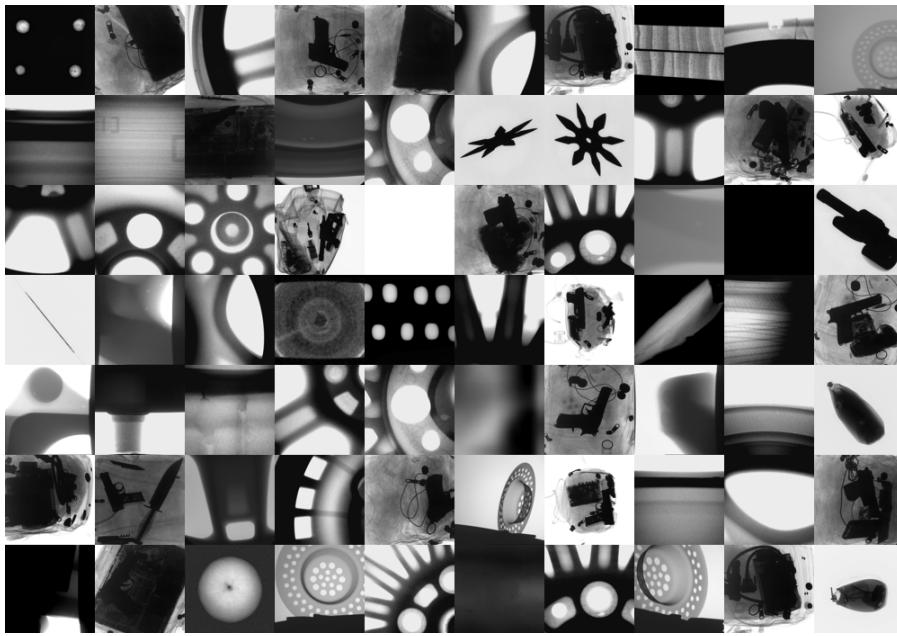


Fig. 1 Random X-ray images of GDXray database.

1 Introduction

Public databases of X-ray images can be found for medical imaging¹, however, to the best knowledge of the authors, up until now there have not been any public databases of digital X-ray images for X-ray testing².

As a service to the X-ray testing community, we collected more than 19,400 X-ray images for the development, testing and evaluation of image analysis and computer vision algorithms. The images are organized in a public database called GDXray: The Grima X-ray database³. In order to illustrate our database, a random selection of 70 X-ray is shown in Fig. 1. The database includes five groups of X-ray images: castings, welds, baggage, natural objects and settings. Each group has several series, and each series several X-ray images. Some samples of each series are illustrated in Fig. 2. Most of the series are annotated or labeled. In those cases, the coordinates of the bounding boxes

¹ See for example a good collection in <http://www.via.cornell.edu/databases/>.

² There are some galleries of X-ray images available on the web with a few samples, see for instance http://www.vidisco.com/ndt_solutions/ndt_info_center/ndt_x-ray_gallery with approximately 50 X-ray images.

³ Grima, from *Grupo de Inteligencia de Máquina*, is the name of our Machine Intelligence Group at the Department of Computer Science of the Pontificia Universidad Católica de Chile <http://grima.ing.puc.cl>. The X-ray images included in GDXray can be used free of charge, for research and educational purposes only. Redistribution and commercial use is prohibited. Any researcher reporting results which use this database should acknowledge the GDXray database by citing this paper.



GDXray: X-ray images for X-ray testing and Computer Vision

As a service to the X-ray testing and Computer Vision communities, we collected more than 19,400 X-ray images for the development, testing and evaluation of image analysis and computer vision algorithms. The images are organized in this public database called GDXray: The GRIMA X-ray database (GRIMA is the name of our Machine Intelligence Group at the Department of Computer Science of the Pontificia Universidad Católica de Chile). The X-ray images included in GDXray can be used free of charge, for research and educational purposes only. Redistribution and commercial use is prohibited. Any researcher reporting results which use this database should acknowledge the GDXray database by citing:

Mery, D.; Riffó, V.; Zscherpel, U.; Mondragón, G.; Lillo, I.; Zuccar, I.; Lobel, H.; Carrasco, M. (2015): GDXray - The Grima database of X-ray images. Department of Computer Science, Universidad Católica de Chile, in collaboration with Institute for Materials Research and Testing (BAM), Berlin.

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GDXray includes five groups of images: [Castings](#), [Welds](#), [Baggage](#), [Nature](#) and [Settings](#). Each group has several series, and each series several X-ray images. For instance, series [C0001](#) contains 72 X-ray images of an aluminum casting (wheel).

GDXray URL: <http://dmery.ing.puc.cl/index.php/material/gdxray>

Fig. 2 Screenshot of GDXray website. Some X-ray images of ten series are shown at the right side: C0001 and C0034 for castings, W0001 and W0003 for welds, B0001 and B0046 for baggage, N0006 (cherry), N0010 (wood) and N0011 (salmon) for natural objects and S0001 for settings (a calibration pattern).

Table 1 Statistics of GDXray database.

Groups	Series	Images	Size (MB)
Castings	67	2,727	307.5
Welds	3	88	209.4
Baggage	77	8,150	2,734.8
Nature	13	8,290	191.9
Settings	7	152	45.5
Total	167	19,407	3,489.0

of the objects of interest or the labels of the images are available. In Table 1 we can see some statistics. The size of GDXray is 3.5 GB and it can be downloaded from our website (see Fig. 2).

In this paper, we will view the structure of GDXray database, a description for each group (with some series examples), and some examples of applications that have been published using images of GDXray.

2 Structure of the database

GDXray is available in a public repository. The repository contains 5 group folders one for each group: Castings, Welds, Baggage, Nature and Settings.

Table 2 Structure of **GDXray**.

Database	Groups	Series	X-ray images
GDXray →			
	Castings	→ C0001	→ C0001_0001.png ... C0001_0072.png
		:	
		→ C0067	→ C0067_0001.png ... C0067_0083.png
	Welds	→ W0001	→ W0001_0001.png ... W0001_0010.png
		:	
		→ W0003	→ W0003_0001.png ... W0003_0068.png
	Baggage	→ B0001	→ B0001_0001.png ... B0001_0014.png
		:	
		→ B0077	→ B0077_0001.png ... B0077_00576.png
	Nature	→ N0001	→ N0001_0001.png ... N0001_0013.png
		:	
		→ N0013	→ N0013_0001.png ... N0013_0006.png
	Settings	→ S0001	→ S0001_0001.png ... S0001_0018.png
		:	
		→ S0007	→ S0007_0001.png ... S0007_0029.png

For each group we define an initial: **C**, **W**, **B**, **N** and **S** respectively. As shown in Tab. 1, each group has several series. Each series is stored in an individual sub-folder of the corresponding group folder. The sub-folder name is **Xssss**, where **X** is the initial of the group and **ssss** is the number of the series. For example, the third series of group Castings is stored in sub-folder **C0003** of folder **Castings** (see more examples in Fig. 2). The X-ray images of a series are stored in file **Xssss_nnnn.png**. Again **Xssss** is the name of the series. The number **nnnn** corresponds to the number of the X-ray image of this series. For example, the fifth X-ray image of series **C0003** is **C0003_0005.png** and is stored in sub-folder **Castings/C0003**. The whole structure is summarized in Table 2. It is worth mentioning that all X-ray images of **GDXray** are stored in ‘png’ (Portable Network Graphics)⁴ 8-bit grayscale format. Additional metadata for each series (such as description of the objects, parameters and description of X-ray imaging system, etc.) are given in an ASCII file called **Xssss_readme.txt** included in sub-folder **Xssss**, e.g., **C0003_readme.txt** for series **Castings/C0003**.

3 Castings

The group Castings contains 2,727 X-ray images arranged in 67 series. The X-ray images were taken mainly from automotive parts (aluminum wheels and knuckles) using an image intensifier. Some examples are illustrated in Fig. 3. The details of each series are given in Table 3. Experiments on these data

⁴ See <http://www.libpng.org/pub/png/>.

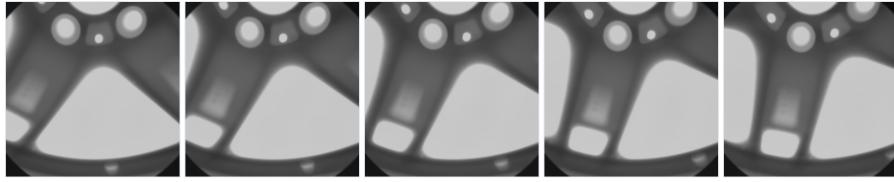


Fig. 3 Some X-ray images of an aluminum wheel (group Castings series C0001).

Table 3 Description of group ‘Castings’ of GDXray.

Series	Images	kpixels	Description	Additional
C0001	72	439.3	Wheel: Rotation each 5 degrees	Annotations for defects, calibration
C0002	90	44.5	Crops of C0001 with and without defects	Annotations for defects
C0003–C0043	37	439.3	Wheels with and without defects	Annotations for defects
C0044–C0051	54–77	65.5	Wheel with small drilled defects	Annotations for defects
C0052–C0054	17–31	440.8	Knuckle with low contrast defects	Annotations for defects
C0055	28	440.8	Sink strainer	Annotations for holes
C0056	10	440.8	Sink strainer high speed	
C0057	31	440.8	Knuckle with low contrast defects	Annotations for defects
C0058–C0067	10–83	440.8	Knuckle with small defects in motion	Annotations for defects

Table 4 Applications of series Castings.

Series	Application	References
C0001	Detection of defects in multiple views	[18, 10, 2, 28, 27, 14]
	Estimation of epipolar geometry with distortion	[16]
	Calibration of X-ray imaging system with image intensifiers	[18]
	Simulation of casting defects	[18]
C0002	Experiments on detection of defects in single views	[8, 4, 29, 15]
C0008	Simulation of casting defects	[6]
C0017	Simulation of casting defects	[7, 20]
C0032	Experiments on detection of defects in multiple views	[10]
C0037	Simulation of casting defects	[7, 20]
C0049	Image restoration in blurred X-ray images	[17]
C0054	Detection of casting on moving castings	[19]
C0055	Image restoration in blurred X-ray images	[17]

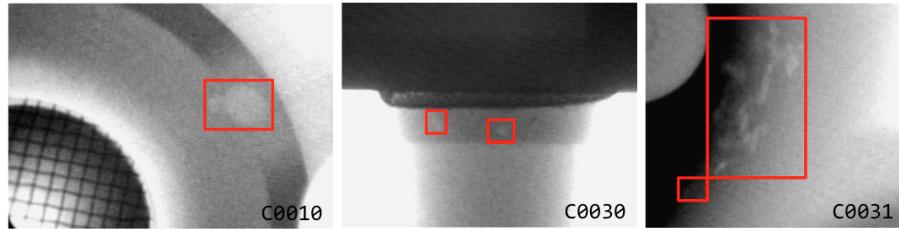


Fig. 4 Some annotated images showing bounding boxes of casting defects.

can be found in several publications as shown in Tab. 4. It is interesting to highlight that series C0001 (see Fig. 3) contains not only a sequence of 72 X-ray images taken from an aluminum wheel by rotating its central axis in 5° , but also annotations of bounding boxes of the ground truth of 226 small defects and the calibration matrix of each image that relates the 3D coordinates of the aluminum wheel with 2D coordinates of the X-ray image.

Table 5 Description of group ‘Welds’ of GDXray.

Series	Images	kpixels	Description	Additional
W0001	10	3323.8	Selection of 10 images of W0003	Annotations for defects. See W0002.
W0002	10	3323.8	Binary ideal segmentation of images of W0001	
W0003	68	6693.8	Radiographs from a round robin test performed by BAM	Excel file with real-values

Table 6 Applications of series Welds.

Series	Application	References
W0001	Detection of defects in welds	[1, 13, 11, 5]
	Simulation of welding defects	[20, 11]
W0002	Evaluation of performance of detection algorithm	[1]
W0003	Detection of defects in welds	[26, 31]

4 Welds

The group Welds contains 88 images arranged in 3 series. The X-ray images were taken by the BAM Federal Institute for Materials Research and Testing, Berlin, Germany⁵. Some examples are illustrated in Fig. 5. The details of each series are given in Table 5. Experiments on these data can be found in several publications as shown in Tab. 6. It is interesting to highlight that series W0001 and W0002 (see Fig. 5) contains not only 10 X-ray images selected from the whole BAM database (series W0003), but also annotations of bounding boxes and the binary images of the ground truth of 641 defects.

Series W0003 contains a collection of 67 digitized radiographs from a round robin test on flaw recognition in welding seams. The NDT films (used with lead screens) were exposed according to ISO 17636-1, testing class A. After development they have been scanned with a LASER scanner LS85 SDR from Lumisys using digitization class DB-9 according to ISO 14096-2. The original 12 bit data depth was rescaled to 8 bits with a linear LUT proportional to optical film density by visual adjustment to the image content. This ensures that all necessary flaw information is still in the 8 bit images⁶. The pixel size is 40.3 micron (630 dpi). The images are 8 bit gray values. In addition, in this directory the file ‘real-values.xls’ contains the true data and the flaw designations according to ISO 6520 and ISO 5817. These true data have been generated using weld sections of 1 cm width starting from the indicated Zero point.

5 Baggage

The group Baggage contains 8,150 X-ray images arranged in 77 series. The X-ray images were taken from different containers such as backpacks, pen cases,

⁵ The X-ray images of series W0001 and W0003 are included in GDXray thanks to the collaboration of the BAM Federal Institute for Materials Research and Testing, Berlin, Germany <http://dir.bam.de/dir.html>.

⁶ The original images in TIFF format are available also in series W0003 as files RRT01.zip (the first 31 images) and RRT02.zip (the last 36 images).

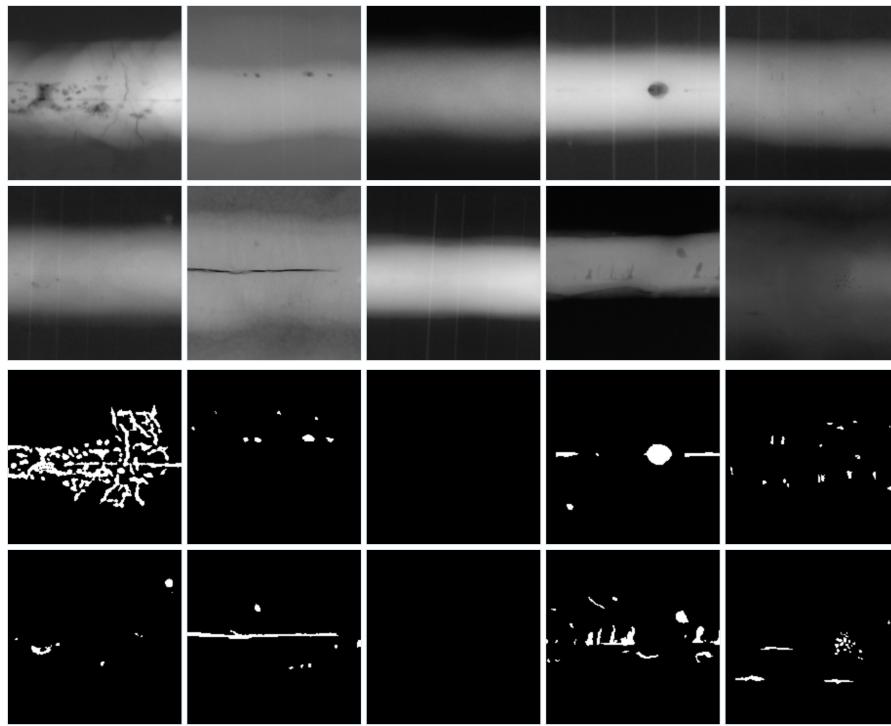


Fig. 5 Some images of group Welds series W0001 (X-ray images) and W0002 (ground truth).

wallets, etc. Some examples are illustrated in Fig. 6 and 7. The details of each series are given in Table 7. Experiments on these data can be found in several publications as shown in Tab. 8. It is interesting to highlight that series B0046, B0047 and B0048 (see for example Fig. 6) contains 600 X-ray images that can be used for automated detection of handguns, shuriken and razor blades (bounding boxes for these objects of interest are available as well). In this case, the training can be performed using series B0049, B0050 and B0051 that includes X-ray images of individual handguns, shuriken and razor blades respectively taken from different points of view as shown in Fig. 7.

6 Natural objects

The group Nature contains 8,290 X-ray images arranged in 13 series. The X-ray images were taken from different natural objects such as salmon filets, fruit and wood pieces. Some examples are illustrated in Fig. 9 and 10. The details of each series are given in Table 9. Experiments on these data can be found in several publications as shown in Tab. 10. It is interesting to highlight that series N0012 and N0013 (see Fig. 11) contains not only 6 X-ray images of salmon filets, but also annotations of bounding boxes and the binary images



Fig. 6 Some X-ray images of a bag containing handguns, *shuriken* and razor blades (group **Baggage** series B0048).

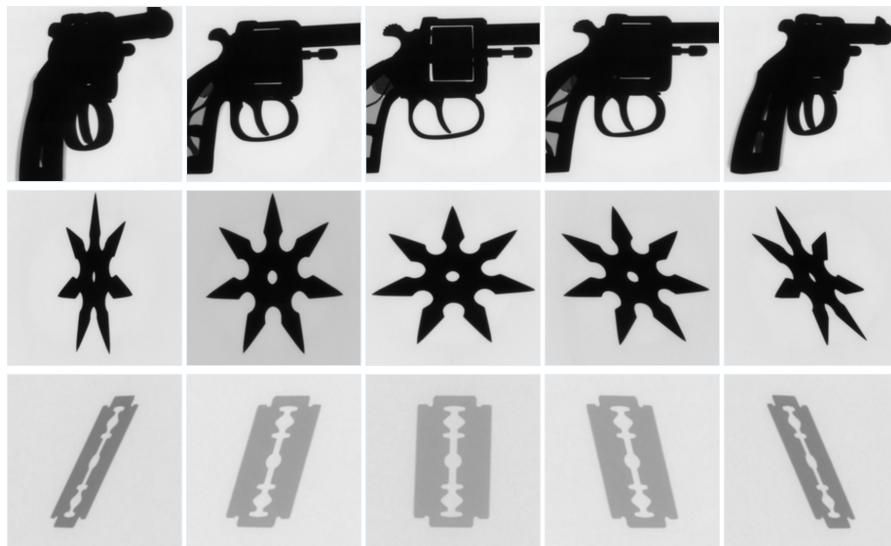


Fig. 7 Some X-ray images of handguns (series B0049), *shuriken* (series B0050) and razor blades (series B0051) of group **Baggage**.

of the ground truth of 73 fish bones. For training proposes, there are more than 7,500 labeled small crops (10×10 pixels), of regions of X-ray of salmon files with and without fish bones in series N0003.

7 Settings

The group Settings contains 151 X-ray images arranged in 7 series. The X-ray images were taken from different calibration objects such checkerboards and

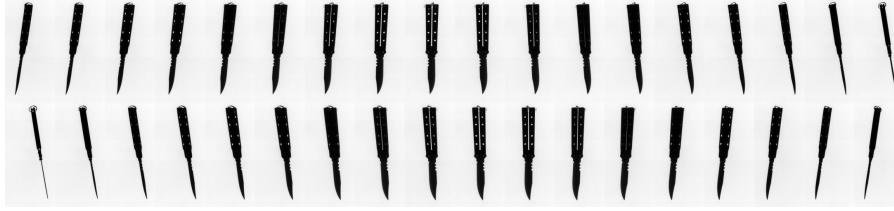


Fig. 8 A knife was rotated in 1^0 and by each position an X-ray image was captured. In this figure, X-ray images at $0^0, 10^0, 20^0, \dots, 350^0$ are illustrated (see series B00008 of group Baggage).

Table 7 Description of group ‘Baggage’ of GDXray.

Series	Images	kpixels	Description	Additional
B0001–B0006	9–14	722.5–5935.1	Pen case with several objects	Annotations for objects
B0007	20	129.6	Razor blade for training	
B0008	361	745.8	Rotation of a knife in 1^0	
B0009–B0043	4–19	276.6	Backpack with handgun and objects	Annotations for handguns
B0044	178	5935.1	Backpack with handgun	Calibration parameters
B0045	90	1287.0	Pen case in 90 positions	Annotations for razor blades
B0046–B0048	200	5412.0–5844.0	Backpack with handguns, shuriken, razor blades	Annotations for objects
B0049–B0051	100–200	165.6–759.5	Handguns, shuriken, and blades for training	
B0052–B0054	144	741.3	Shuriken with 6,7,8 points for training	
B0055–B0057	800–1600	16.9–18.1	200 4, 6, 8-image sequences of single objects	Labels
B0058	64	196.6	Crops of clips, springs, razor blades and others	Labels. See B0059
B0059	64	196.6	Binary ideal segmentation of images of B0058	Labels. Original images in B0058
B0060	2	5935.1	Images for dual-energy experiments	Annotations for shuriken
B0061–B0073	17–25	2856.1–3656.8	Razor blade in cases	Annotations for razor blades
B0074	37	2856.1	Rotation of a door key in 10^0	
B0075–B0077	576	1581.8–5935.1	Knife in 576 positions	

Table 8 Applications of series Baggage.

Series	Application	References
B0005	Experiments on detection of pins in multiple views	[30, 10]
	Detection of razor blades using active vision	[30]
B0007	Training of a classifier of razor blades	[30]
B0009–43	Experiments on detection of handguns	[23, 3]
B0045	Experiments on detection of objects in multiple views	[12, 24]
	Active vision	[30]
B0055	Experiments on detection of objects in sequences of four views	[12]
B0056	Experiments on detection of objects in sequences of six views	[12]
B0057	Experiments on detection of objects in sequences of eight views	[12]
B0058	Training of a classifier for clips, springs and razor blades	[12, 24]
B0061–73	Detection of razor blades using active vision	[30]

Table 9 Description of group ‘Nature’ of GDXray.

Series	Images	kpixels	Description	Additional
N0001	13	5935.1	Apples	
N0002	200	10.0	Cropped images of 100×100 pixels for fish bone detection	Labels
N0003	7,697	0.1	Cropped images of 10×10 pixels for fish bone detection	Labels
N0004	20	143.3	Static noisy images of a wood piece	
N0005	9	4076.7	Apples	Annotations for apples
N0006	27	5935.1	Cherries	Annotations for cherries
N0007	8	5935.1	Cherries	Annotations for cherries
N0008	3	5935.1	Kiwis	Annotations for cherries
N0009	39	585.0	Wood pieces	
N0010	99	83.6	Wood pieces	
N0011	163	5935.1	Salmon filets	
N0012	6	5935.1	Selected 6 images of N0011	Annotation for fish bones. See N0013
N0013	6	5935.1	Binary ideal segmentation of N0012	Original images in N0012

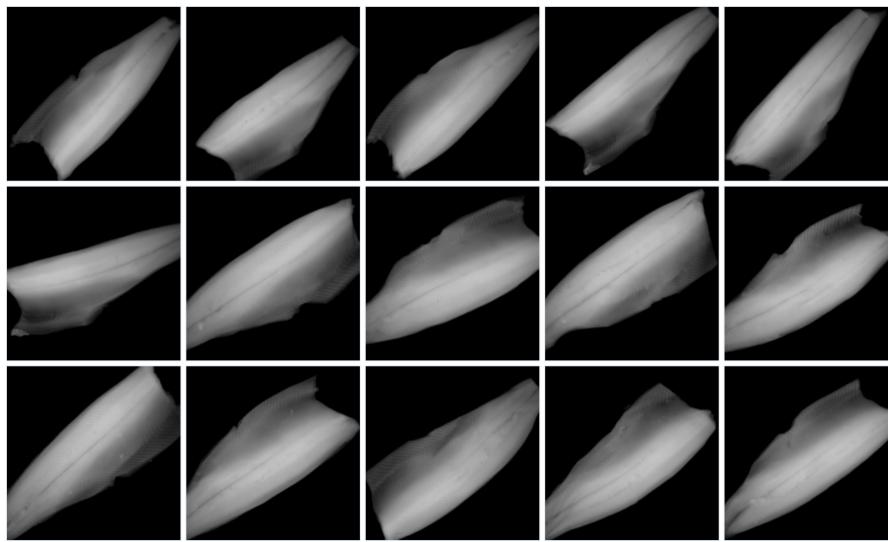


Fig. 9 Some X-ray images of salmon filets (group **Nature** series N0011).

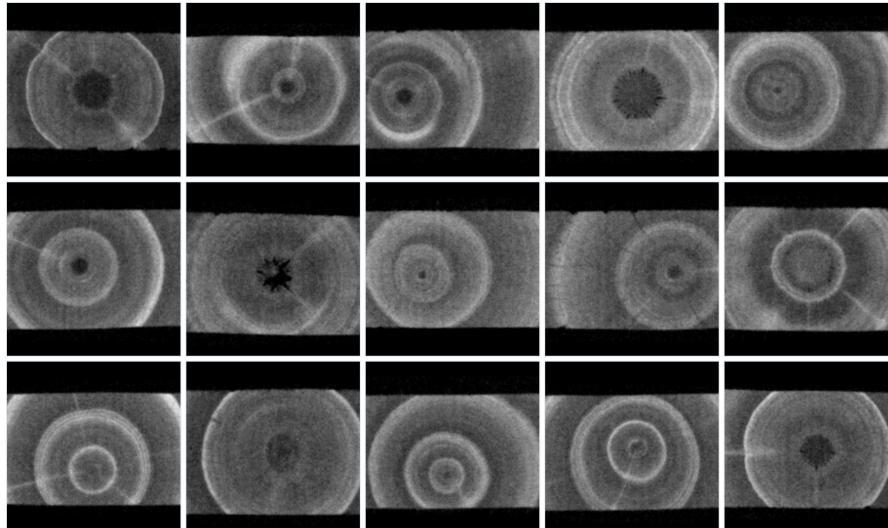


Fig. 10 Some X-ray images of wood (group **Nature** series N0010).

Table 10 Applications of series Nature.

Series	Application	References
N0003	Automated design of a visual food quality system	[22]
N0003	Automated fish bone detection	[21]
N0008	Quality control of kiwis	[25]
N0011	Automated fish bone detection	[21]

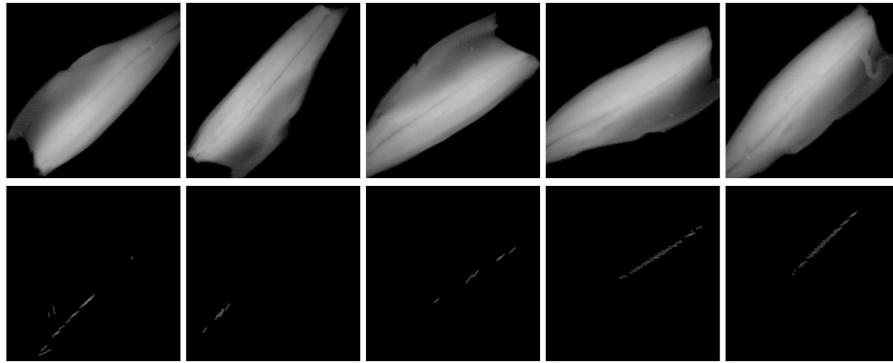


Fig. 11 Some images of group **Nature** series S0012 (X-ray images of salmon filets) and S0013 (ground truth for fish bones).

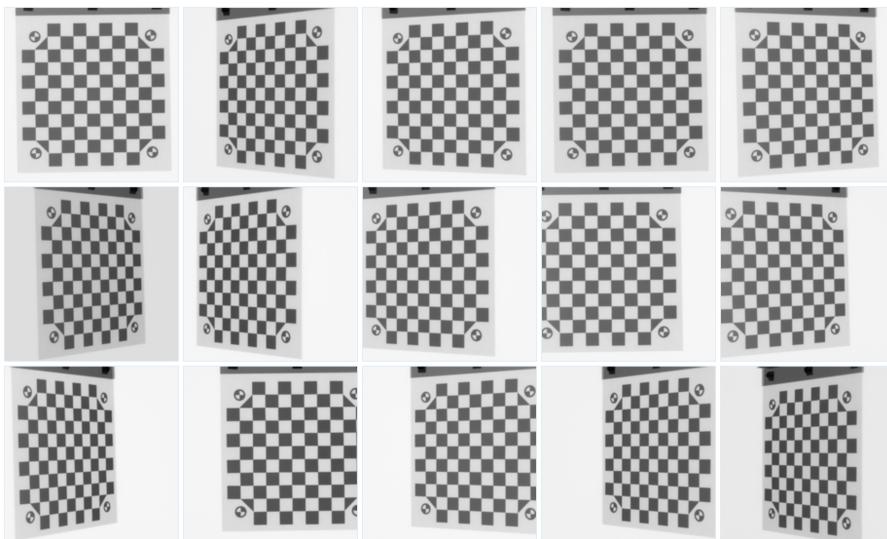


Fig. 12 Some X-ray images of a cooper checkerboard used by calibration (group **Settings** series S0001).

3D objects with regular patterns. Some examples are illustrated in Fig. 12. The details of each series are given in Table 11. Experiments on these data can be found in several publications as shown in Tab. 12. It is interesting to highlight that series S0001 (see Fig. 12) contains not only 18 X-ray images of a copper checkerboard, but also the calibration matrix of each view. In addition, series S0007 can be used for modeling the distortion of an image intensifier. The coordinates of each hole of the calibration pattern in each view are available, and the coordinates of the 3D model are given as well.

Table 11 Description of group ‘Settings’ of GDXray.

Series	Images	kpixels	Description	Additional
S0001	18	5935.1	Checkerboard captured by flat panel	Calibration parameters
S0002	1	427.9	Regular grid captured by image intensifier	Coordinates of calibration points
S0003	36	440.8	Circular pattern in different positions	Manipulator coordinates, 3D coordinates
S0004	23	440.8	Circular pattern in different positions	Manipulator coordinates, 3D coordinates
S0005	27	440.8	Circular pattern in different positions	Manipulator coordinates, 3D coordinates
S0006	17	440.8	Circular pattern in different positions	Manipulator coordinates, 3D coordinates
S0007	29	440.8	Circular pattern in different positions	Coordinates of calibration points (2D & 3D)

Table 12 Applications of series Settings.

Series	Application	References
S0001	Calibration of a multiple view X-ray imaging system for active vision	[30]
S0002	Distortion model of an image intensifier	[16, 18]
S0007	Explicit geometric model of a radioscopic imaging system	[9]

8 Conclusions

In this paper, we presented the details of a new public dataset called GDXray. It consists of more than 19,400 X-ray images. The database includes five groups of X-ray images: castings, welds, baggage, natural objects and settings. Each group has several series and X-ray images with many labels and annotations that can be used for training and testing purposes in computer vision algorithms. To the best knowledge of the authors, up until now there have not been any public databases of digital X-ray images for X-ray testing.

In this paper, we explained the structure of the GDXray database, we gave a description for each group (with some series examples), and we presented some examples of applications that have been published using images of GDXray.

We believe that GDXray represents a relevant contribution to the X-ray testing community. On the one hand, students, researchers and engineers can use these X-ray images to develop, test and evaluate image analysis and computer vision algorithms without purchasing expensive X-ray equipment. On the other hand, these images can be used as a benchmark in order to test and compare the performance of different approaches on the same data. Moreover, the database can be used in the training programs of human inspectors.

References

1. Carrasco, M., Mery, D.: Segmentation of welding defects using a robust algorithm. *Materials Evaluation* **62**(11), 1142–1147 (2004)
2. Carrasco, M., Mery, D.: Automatic multiple view inspection using geometrical tracking and feature analysis in aluminum wheels. *Machine Vision and Applications* **22**(1), 157–170 (2011)
3. Damashek, A., Doherty, J.: Detecting guns using parametric edge matching. Tech. Rep. Project for Computer Vision Course: CS231A, Stanford University (2015)
4. Ghoreyshi, A., Vidal, R., Mery, D.: Segmentation of circular casting defects using a robust algorithm. *Insight-Non-Destructive Testing and Condition Monitoring* **47**(10), 615–617 (2005)
5. Hernández, S., Sáez, D., Mery, D., da Silva, R., Sequeira, M.: Automated defect detection in aluminium castings and welds using neuro-fuzzy classifiers. In: Proceedings

- of the 16th World Conference on Non-Destructive Testing (WCNDT–2004). Montreal (2004)
- 6. Huang, Q., Wu, Y., Baruch, J., Jiang, P., Peng, Y.: A template model for defect simulation for evaluating nondestructive testing in X-radiography. *Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions* **39**(2), 466–475 (2009)
 - 7. Mery, D.: A new algorithm for flaw simulation in castings by superimposing projections of 3D models onto X-ray images. In: Proceedings of the XXI International Conference of the Chilean Computer Science Society (SCCC-2001), pp. 193–202. IEEE Computer Society Press, Punta Arenas (2001)
 - 8. Mery, D.: Crossing line profile: a new approach to detecting defects in aluminium castings. *Proceedings of the Scandinavian Conference on Image Analysis (SCIA 2003), Lecture Notes in Computer Science* **2749**, 725–732 (2003)
 - 9. Mery, D.: Explicit geometric model of a radioscopic imaging system. *NDT & E International* **36**(8), 587–599 (2003)
 - 10. Mery, D.: Automated detection in complex objects using a tracking algorithm in multiple X-ray views. In: Proceedings of the 8th IEEE Workshop on Object Tracking and Classification Beyond the Visible Spectrum (OTCBVS 2011), in Conjunction with CVPR 2011, Colorado Springs, pp. 41–48 (2011)
 - 11. Mery, D.: Automated detection of welding defects without segmentation. *Materials Evaluation* **69**(6), 657–663 (2011)
 - 12. Mery, D.: Inspection of complex objects using multiple-X-ray views. *IEEE/ASME Transactions on Mechatronics* **20**(1), 338–347 (2015)
 - 13. Mery, D., Berti, M.A.: Automatic detection of welding defects using texture features. *Insight-Non-Destructive Testing and Condition Monitoring* **45**(10), 676–681 (2003)
 - 14. Mery, D., Carrasco, M.: Automated multiple view inspection based on uncalibrated image sequences. *Lecture Notes in Computer Science* **3540**, 1238–1247 (2005)
 - 15. Mery, D., Chacón, M., Muñoz, L., González, L.: Automated inspection of aluminium castings using fusion strategies. *Materials Evaluation* (2005). In Press
 - 16. Mery, D., Filbert, D.: The epipolar geometry in the radioscopy: Theory and application. at - Automatisierungstechnik **48**(12), 588–596 (2000). (in German)
 - 17. Mery, D., Filbert, D.: A fast non-iterative algorithm for the removal of blur caused by uniform linear motion in X-ray images. In: Proceedings of the 15th World Conference on Non-Destructive Testing (WCNDT–2000). Rome (2000)
 - 18. Mery, D., Filbert, D.: Automated flaw detection in aluminum castings based on the tracking of potential defects in a radioscopic image sequence. *IEEE Trans. Robotics and Automation* **18**(6), 890–901 (2002)
 - 19. Mery, D., Filbert, D.: Automated inspection of moving aluminium castings. In: 8th European Conference on Non-Destructive Testing (ECNDT 2002). Barcelona (2002)
 - 20. Mery, D., Hahn, D., Hitschfeld, N.: Simulation of defects in aluminum castings using cad models of flaws and real x-ray images. *Insight* **47**(10), 618–624 (2005)
 - 21. Mery, D., Lillo, I., Riffó, V., Soto, A., Cipriano, A., Aguilera, J.: Automated fish bone detection using X-ray testing. *Journal of Food Engineering* **2011**(105), 485–492 (2011)
 - 22. Mery, D., Pedreschi, F., Soto, A.: Automated design of a computer vision system for visual food quality evaluation. *Food and Bioprocess Technology* **6**(8), 2093–2108 (2013)
 - 23. Mery, D., Riffó, V., Mondragón, G., Zuccar, I.: Detection of regular objects in baggages using multiple X-ray views. *Insight* **55**(1), 16–21 (2013)
 - 24. Mery, D., Riffó, V., Zuccar, I., Pieringer, C.: Automated X-ray object recognition using an efficient search algorithm in multiple views. In: Proceedings of the 9th IEEE CVPR workshop on Perception Beyond the Visible Spectrum, Portland (2013)
 - 25. Mondragón, G., Leiva, G., Aguilera, J., Mery, D.: Automated detection of softening and hard columella in kiwifruits during postharvest using X-ray testing. In: Proceedings of International Congress on Engineering and Food (2011)
 - 26. Perner, P., Zscherpel, U., Jacobsen, C.: A comparison between neural networks and decision trees based on data from industrial radiographic testing. *Pattern Recognition Letters* **22**(1), 47 – 54 (2001)
 - 27. Pieringer, C., Mery, D.: Flaw detection in aluminium die castings using simultaneous combination of multiple views. *Insight* **52**(10), 548–552 (2010)
 - 28. Pizarro, L., Mery, D., Delpiano, R., Carrasco, M.: Robust automated multiple view inspection. *Pattern Analysis and Applications* **11**(1), 21–32 (2008)

-
- 29. Ramírez, F., Allende, H.: Detection of flaws in aluminium castings: a comparative study between generative and discriminant approaches. *Insight-Non-Destructive Testing and Condition Monitoring* **55**(7), 366–371 (2013)
 - 30. Riffó, V., Mery, D.: Active X-ray testing of complex objects. *Insight* **54**(1), 28–35 (2012)
 - 31. da Silva, R.R., Siqueira, M.H., de Souza, M.P.V., Rebello, J.M., Calôba, L.P.: Estimated accuracy of classification of defects detected in welded joints by radiographic tests. *NDT & E International* **38**(5), 335–343 (2005)