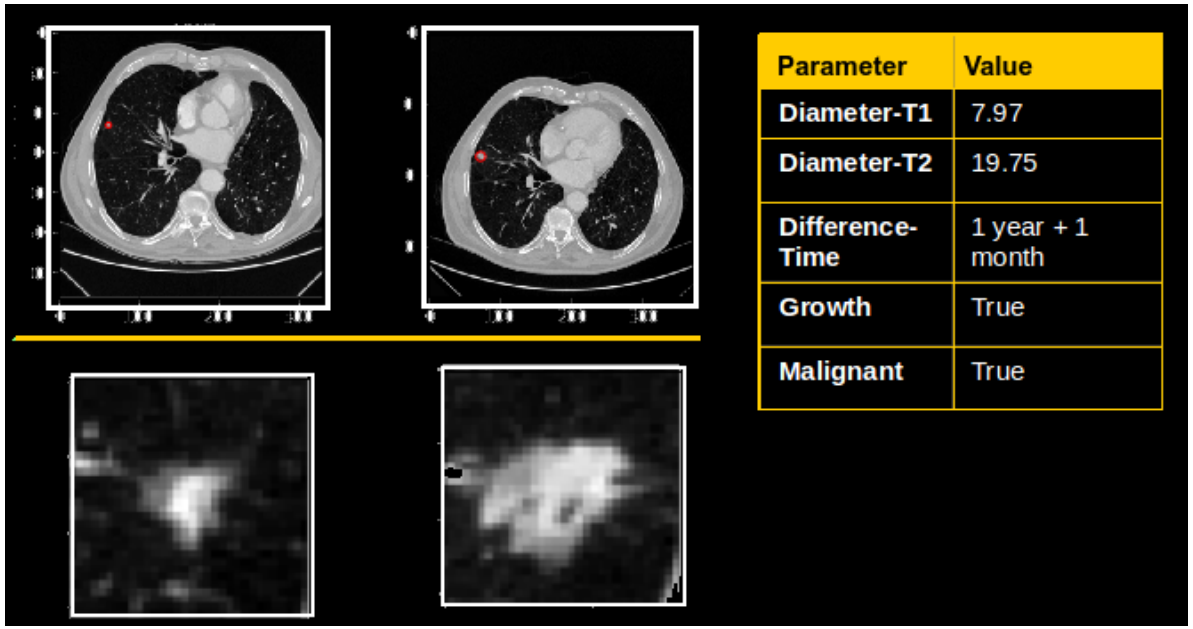
Pulmonary Nodule Malignancy Classification Using Temporal Evolution with Two-Stream 3D Convolutional Neural Networks

X. Rafael-Palou[1,2], A. Aubanell[3], I. Bonavita[2], M. Ceresa[1], G. Piella[1], V. Ribas[2], M. González Ballester[2,4]

1 BCN Medtech, Universitat Pompeu Fabra, Barcelona, Spain
2 Eurecat, Centre Tecnològic de Catalunya, eHealth Unit, Barcelona, Spain
3 Vall d'Hebron University Hospital
4 ICREA, Barcelona, Spain

Motivation

- **CT Nodule malignancy assessment** is complex, time-consuming and error-prone
- **Visual inspection + quantification** of current and follow-up nodules

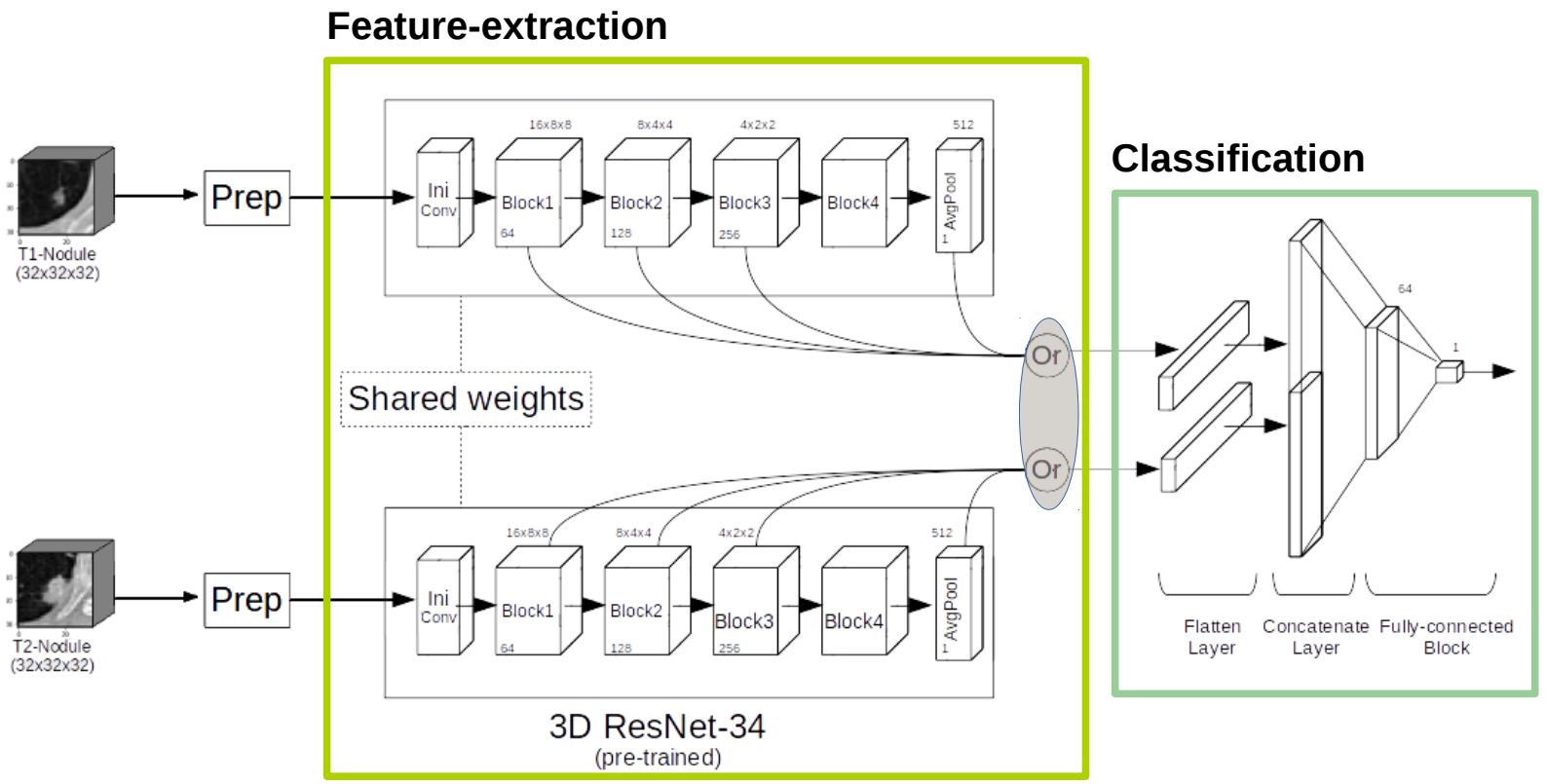


Parameter	Value
Diameter-T1	7.97
Diameter-T2	19.75
Difference-Time	1 year + 1 month
Growth	True
Malignant	True

- **Current accurate predictive models** (>86%) use datasets of nodules taken at single time-points and labels from visual judgements [Dey et al., 2018; Causey et al., 2018]
- Need of classifiers **using nodule temporal evolution** (>1 image) and **cancer confirmed cases** (e.g. biopsy)

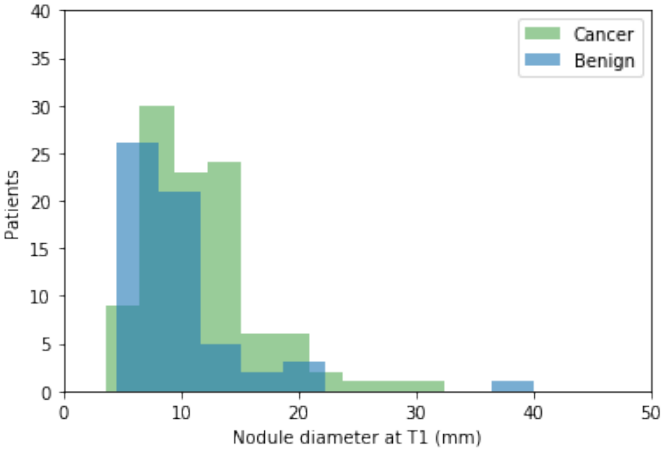
Two stream 3D CNN

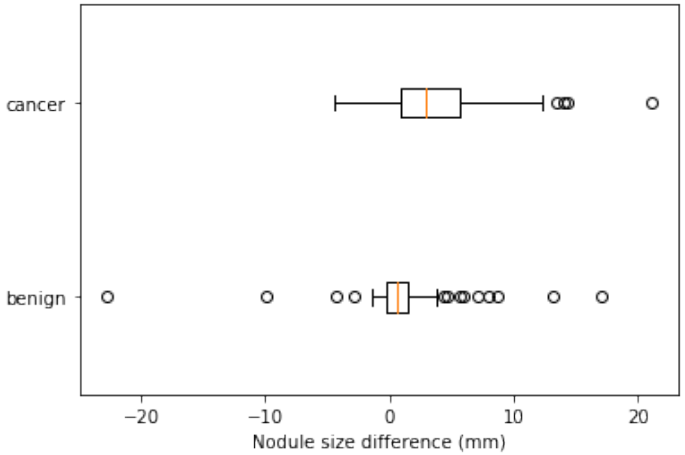
Input	Patches of centered nodule volumes
Prep	HU Clipping + Normalization
FE	Two copies of pre-trained ResNet-34 [Bonavita et al., 2019] from LUNA-16 [Setio et al., 2017] Generation of feature map pairs at different levels of the Nets
CLS	Flatten + concatenation of feature map pairs Fully connected bloc: FC + BNorm + Relu + DropOut Sigmoid Layer



Dataset

- **Collected data**
  - 161 patients, CT pairs at T1,T2
  - 103 cancer - Histopathological confirmed
  - 58 benign - No growth or stability during >2 years
  - 1 nodule per patient
  - Incidental nodules (≥ 5mm)
  - Time interval (1 month – 6 years)
  - Annotations (centroid, diameter) from 2 radiologists
- **Data preparation**
  - Patches of 32x32x32 nodule centered
  - Random stratified partitions: train (70%) / test
  - 10-fold Cross-validation

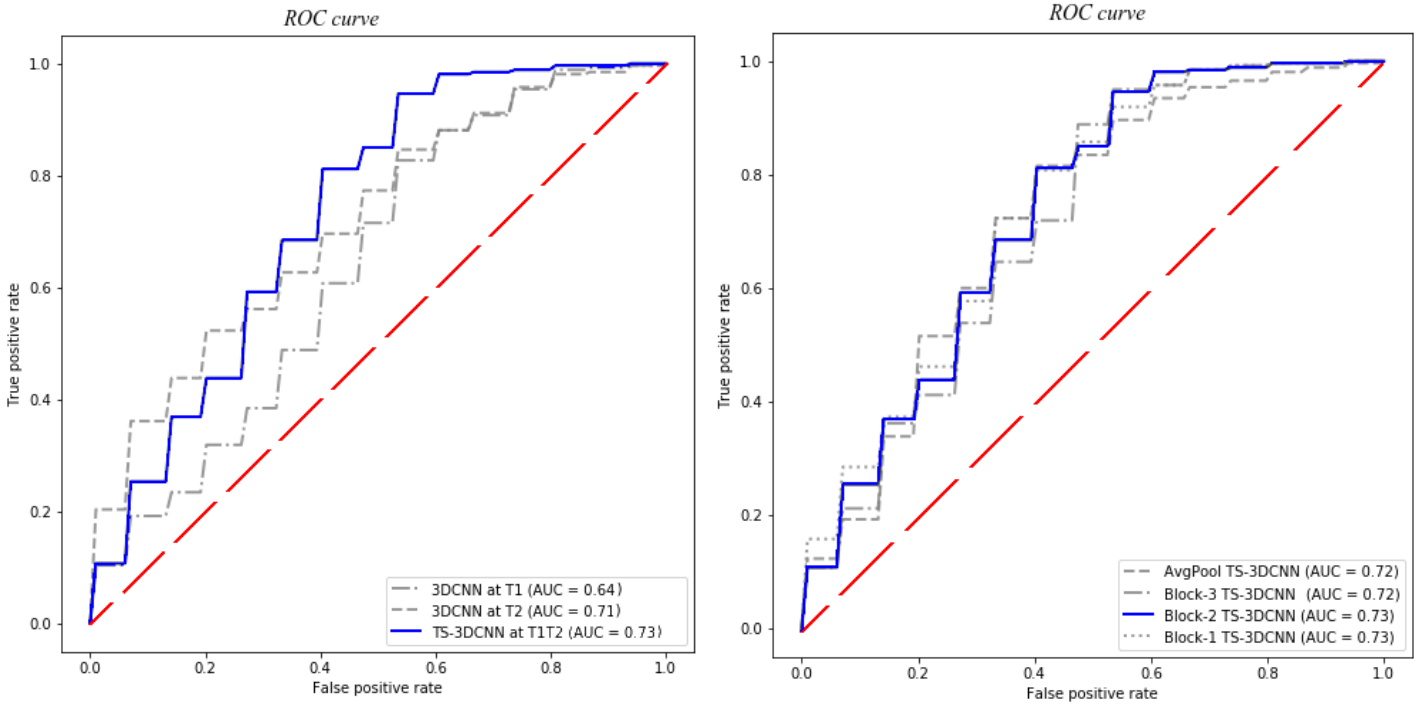




Results

Performance comparison of the TS-3DCNN vs 3DCNN using single nodule image

Model	Time	Feats	Test F1	Test Prec	Test Rec
3DCNN	T1	Block2	0.658	0.754	0.657
3DCNN	T2	AvgPool	0.686	**0.782**	0.650
TS-3DCNN	T1T2	Block2	**0.770**	0.764	**0.792**



Performance comparison (ROC-curves)

Conclusions & Future works

- Trained a Lung cancer classifier on a longitudinal cohort (>160 confirmed cases)
- Classifier learns from series of two 3D nodule volumes
  - Same patient
  - Different timepoints
- Transfer learning from LUNA-16 dataset (> 750K candidates)
- Extracted features from several levels do not enhance performance
- Results show that our method (TS-3DCNN) improves between 12% and 9% respect 3D networks with single nodule images
- Future work:
  - More patient data and from more time-points
  - Incorporate strategies to enable capture nodule evolution (such as RNN)

Thank you!

javier.rafael01@estudiant.upf.edu

xavier.rafael@eurecat.org

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