Comparing the Performance of Man and Machine for TB Screening in Chest Radiographs

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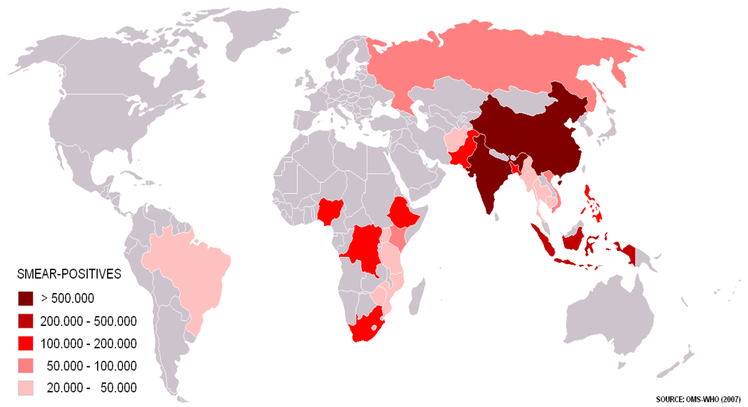
Tuberculosis

Tuberculosis (TB) is a major global health problem. It is an infectious disease caused by the bacillus Mycobacterium tuberculosis, which typically affects the lungs.



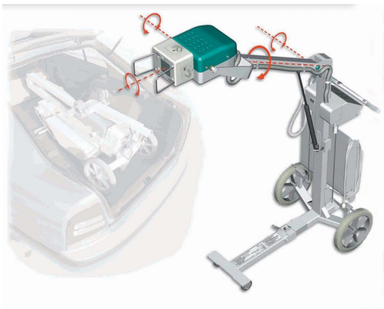
It is most prevalent in sub-Saharan Africa and Southeast Asia, where widespread poverty and malnutrition reduce resistance to the disease. With an estimated 9 million new cases occurring every year, TB is a major health problem in developing countries.

One of the most cost effective approaches to screen TB is to use chest x-rays (CXR). TB manifestations can be diagnosed by reviewing a CXR, which is a mandatory part of every evaluation for TB.

TB Screening Project

We are building a TB detection system for AMPATH (The Academic Model Providing Access to Healthcare).

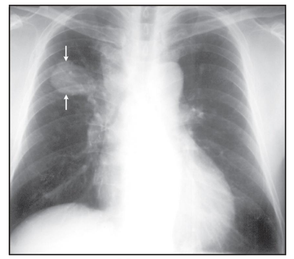
AMPATH is a partnership between Moi University School of Medicine and Moi Teaching and Referral Hospital (Kenya), and a consortium of U.S. medical schools under the leadership of Indiana University. AMPATH provides drug treatment and health education for HIV/AIDS control in Kenya.

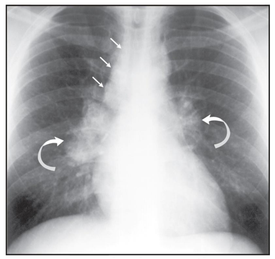


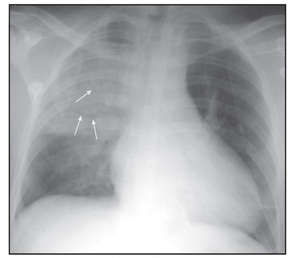
Mobile x-ray scanners will be deployed in rural areas in Kenya to screen potential TB patients. Because there is a shortage of radiological services in Kenya our main goal is to provide Moi University Hospital with a computer aided diagnosis system that can automatically detect whether a person has TB or not. Our software will allow screening of large populations in rural areas.

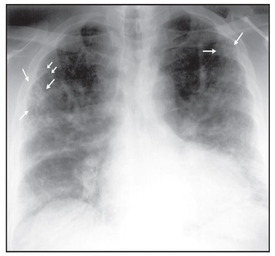
TB Manifestations

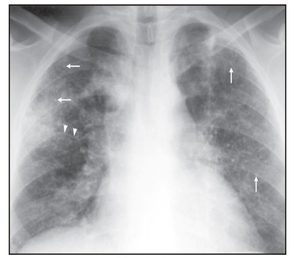
Different TB manifestations in CXRs. They vary in intensity, texture, and shape (Daley, Gotway, Jasmer).

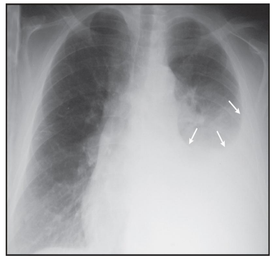

Mass

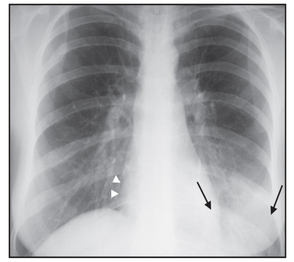

Lymphadenopathy

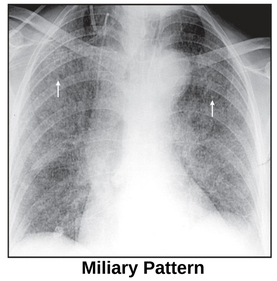

Opacity


Reticulation


Nodules


Pleural Effusion


Silhouette


Miliary Pattern

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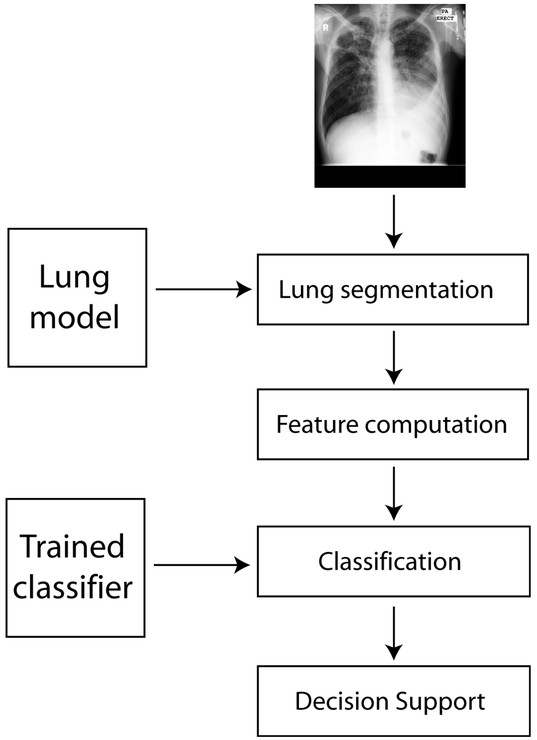
Data

We use a CXR set collected within the tuberculosis control program of the Department of Health and Human Services of Montgomery County, Maryland. This Montgomery set contains 138 posteroanterior CXRs, among which 80 CXRs are normal and 58 CXRs are abnormal with manifestations of TB. The abnormal CXRs cover a wide range of TB-related abnormalities, including effusions and miliary patterns. For the Montgomery set, we know the ground-truth radiology reports that have been confirmed by clinical tests, patient history, etc.

System Architecture



Radiologist Performance

Radiologist Agreement on Montgomery CXRs:

Radiologist A \ Radiologist B	+	-	
+	69	15	84
-	6	48	54
	75	63	138

Agreement: 84.8%
K ≈ 0.69 (moderate)

Comparing Human Consensus Performance with Ground Truth of Montgomery CXRs:

Ground Truth \ Consensus	+	-	
+	58	0	58
-	25	55	80
	83	55	138

Sensitivity: 100%
Specificity: 68.8%
Accuracy: 81.9%

Stefan Jaeger, Alexandros Karargyris, Sema Candemir, Les Folio, Jenifer Siegelman, Fiona Callaghan, Zhiyun Xue, Kannappan Palaniappan, Rahul Singh, Sameer Antani, George Thoma, Yi-Xiang Wang, Pu-Xuan Lu, Clement McDonald. **Automatic Tuberculosis Screening Using Chest Radiographs.** *IEEE Transactions on Medical Imaging* (to appear).

Acknowledgment

This research was supported by the Intramural Research Program of the National Institutes of Health (NIH), National Library of Medicine (NLM), Lister Hill National Center for Biomedical Communications (LHNCBC).

Man-Machine Comparison

Comparing Machine Performance with Ground Truth of Montgomery CXRs:

Ground Truth \ Machine	+	-	
+	43	15	58
-	15	65	80
	58	80	138

Sensitivity: 74.1%
Specificity: 81.3%
Accuracy: 78.3%

Comparing Machine and Radiologist Consensus for Montgomery CXRs:

Machine \ Consensus	+	-	
+	89	19	108
-	24	6	30
	113	25	138

Theoretical Human-Machine Accuracy: 95.7%

Conclusion

The performance of our TB screening software approaches the performance of radiologists when tested on CXRs from a local TB clinic.

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