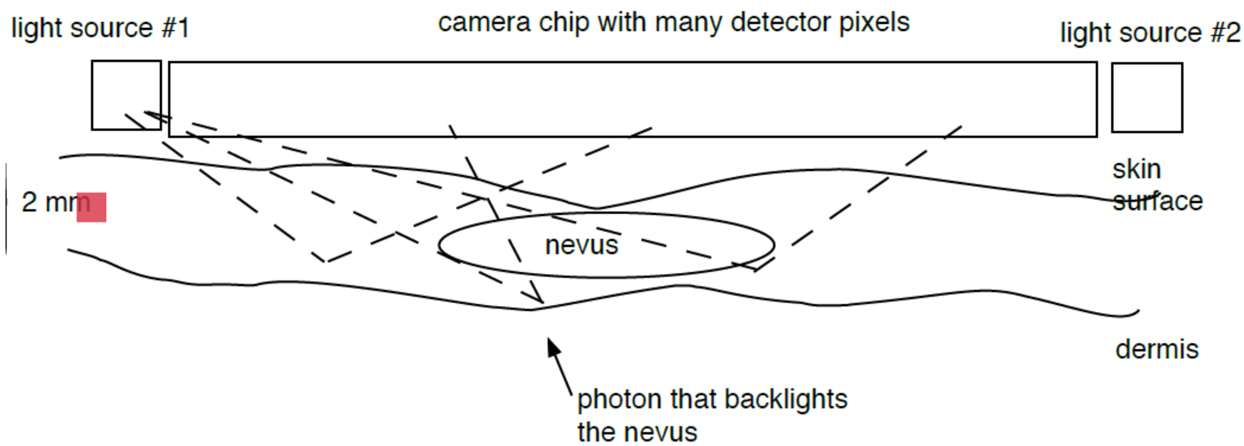
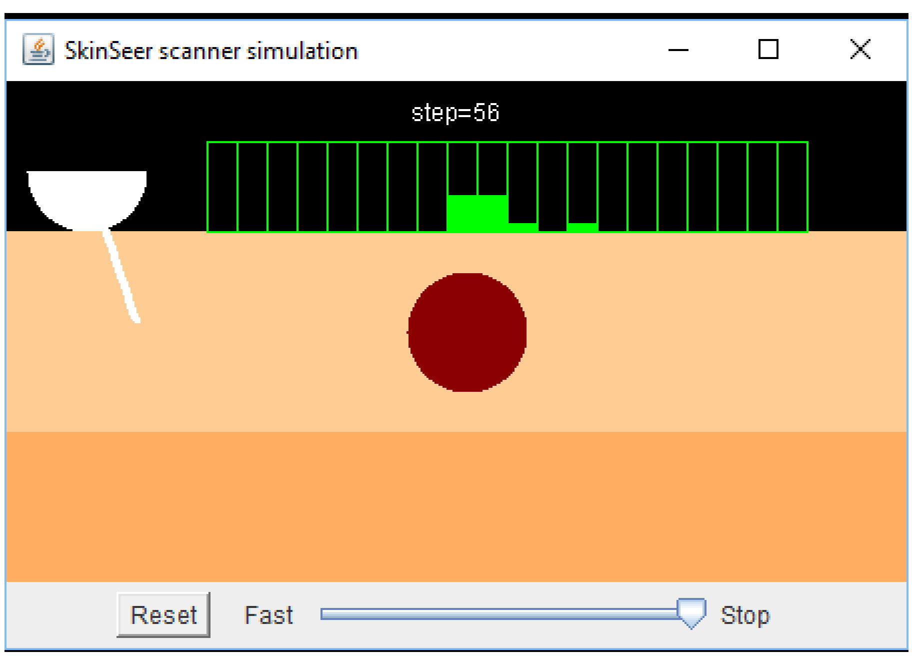
SkinSeer skin scanner simulation

This is a toy simulation of a hand-held skin scanner that Dick Gordon came up with for detecting dangerous skin conditions. A skin nevus become dangerous when it penetrates the dermis. In Dick's original sketch below a nevus is being illuminated by light sources and penetrate the epidermis, dermis, and nevus. A chip containing light detectors captures photons, providing information to diagnose the situation.

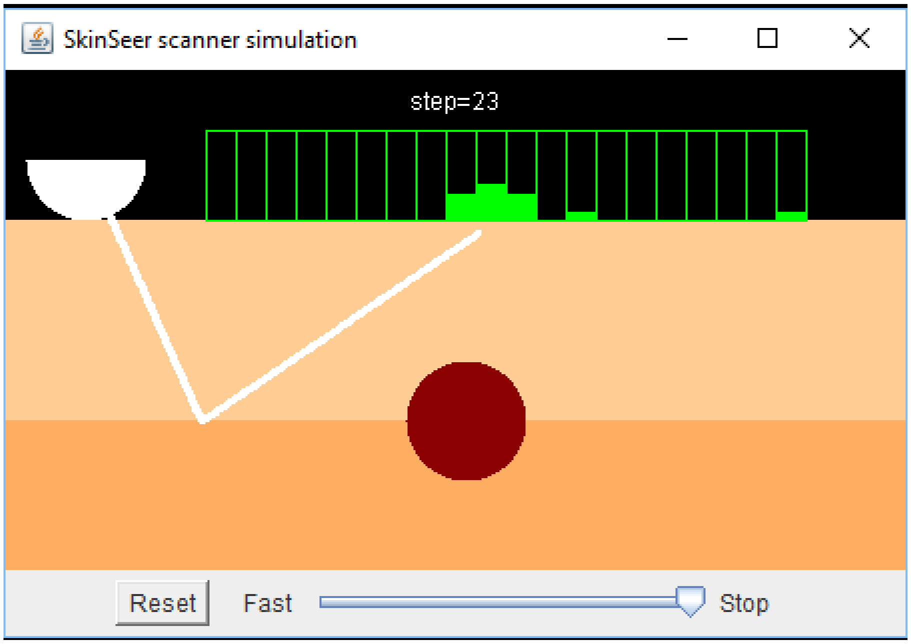


Supervised learning

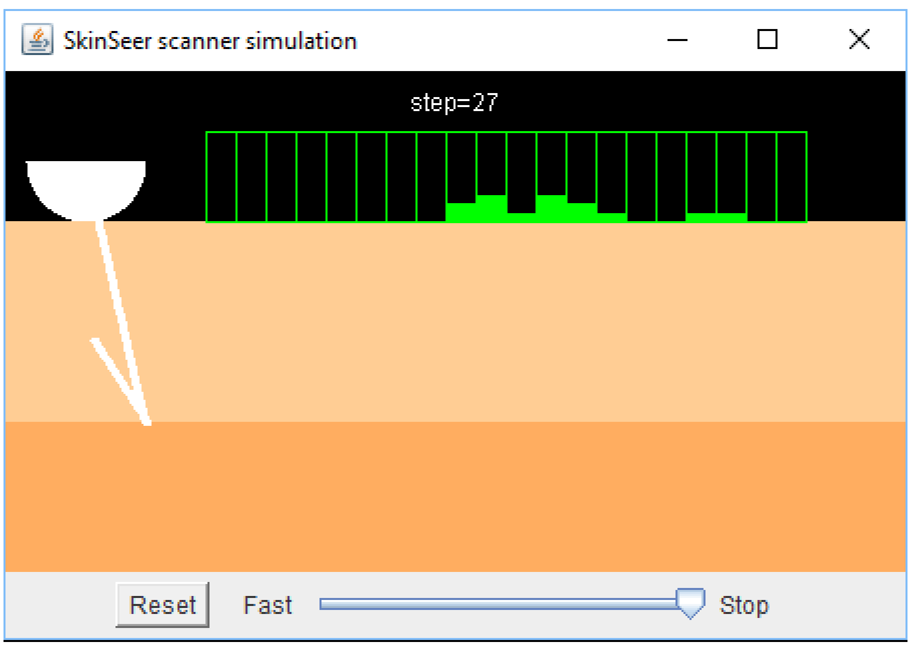
The toy simulation is heavily parameterized, but for a simple demo three possible nevus conditions were configured, as shown below



Nevus in epidermis



Nevus penetrating dermis



No nevus

500 randomly angled photons were emitted for each scan. The epidermis was considered to be transparent, and nevus considered to be 100% light absorbing, and the dermis scattered light hitting it.

The follow is a sample of the data generated. The first 20 columns are the photon counts for the detectors. The last column is the classification of the scan as “ok” (nevus in epidermis or no nevus) or “dangerous” (nevus penetrating dermis).

0	0	0	0	0	0	0	0	39	29	5	0	10	0	0	0	0	0	0	0	ok
0	0	0	0	0	0	0	0	51	73	38	25	21	7	15	12	11	5	8	16	ok
0	0	0	0	0	0	0	0	55	83	31	32	17	11	10	13	14	4	6	12	ok
0	0	0	0	0	0	0	0	50	63	34	22	17	11	15	12	18	6	4	11	ok
0	0	0	0	0	0	0	0	54	67	41	25	19	9	15	7	11	12	8	9	ok
0	0	0	0	0	0	0	0	62	59	17	9	3	3	5	8	9	7	5	11	danger
0	0	0	0	0	0	0	0	40	24	2	0	11	0	0	0	0	0	0	0	ok
0	0	0	0	0	0	0	0	38	33	2	0	10	0	0	0	0	0	0	0	ok
0	0	0	0	0	0	0	0	37	25	3	0	10	0	0	0	0	0	0	0	ok
0	0	0	0	0	0	0	0	39	24	9	0	12	0	0	0	0	0	0	0	ok
0	0	0	0	0	0	0	0	53	65	43	30	22	22	6	6	10	5	7	12	ok
0	0	0	0	0	0	0	0	45	83	30	19	20	11	19	11	13	6	6	5	ok
0	0	0	0	0	0	0	0	50	58	32	23	25	21	17	5	7	7	8	9	ok
0	0	0	0	0	0	0	0	61	73	34	23	11	11	17	10	11	6	8	10	ok
0	0	0	0	0	0	0	0	42	64	37	35	17	15	15	8	11	3	9	7	ok
0	0	0	0	0	0	0	0	47	58	39	29	14	21	18	11	12	5	6	8	ok
0	0	0	0	0	0	0	0	38	26	6	0	8	0	0	0	0	0	0	0	ok
0	0	0	0	0	0	0	0	42	81	39	26	21	18	19	7	11	13	6	8	ok
0	0	0	0	0	0	0	0	54	70	36	34	13	11	12	6	12	6	6	14	ok
0	0	0	0	0	0	0	0	41	69	41	26	27	11	21	14	11	8	8	6	ok
0	0	0	0	0	0	0	0	53	64	11	5	4	6	2	5	17	8	10	11	danger

The dataset was then input into a deep learning neural network to learn to classify the photon count configurations. The following diagram shows the H2O.ai (a popular machine learning package) output. The ROC curve plots the tpr (true positive rate vs. the false positive rate) for varying detection thresholds. The line runs along the right axis which is perfect classification.

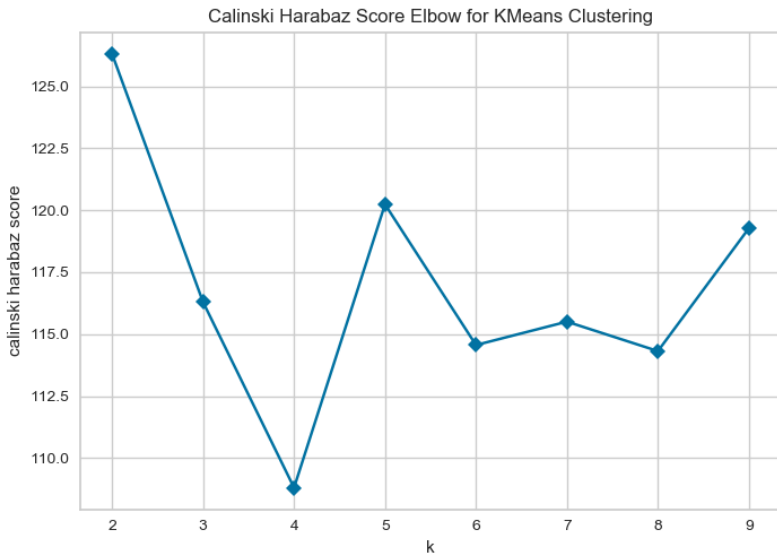
Of course this is a simplified demo but it is intended to suggest that machine learning algorithms might be able to do this task in a real device.

Anomaly detection with unsupervised learning/clustering

A major issue with supervised learning is that it requires the classifications of feature vectors as to whether they indicate melanoma. This would probably require recruiting experts that in typically work with known inputs such as tomography and/or biopsy images. These images would have to be generated and provided to experts.

One way to skirt this might be to consider melanoma as an anomalous condition that would present as a statistical fringe case. Using the simulator, and generating cases for nevus-absent, small-nevus, and large nevus in proportions of 75%, 20%, and 5% respectively, the photon detector vectors were examined with a clustering metric as shown below. The graph indicates that the outputs are best organized as 4 clusters. What this means is that the cases are likely statistically distinguishable.

Of course whether this holds under actual conditions remains to be seen. If it does, however, a user's readings over a significant scan area might be used to detect anomalous conditions that the user would be notified about. In addition, it should also be possible to consult anonymous aggregated user scans to improve the detection performance.



The java and python code is here:

https://github.com/dialectek/SkinSeer

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