KEYNOTE: SOME NOTES ON THE TECHNOLOGY OF RECOGNITION

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We are here today, I take it, to appraise what has been done, and to discern the future, if we may. I notice that a man's worth these times is in the words he speaks and writes. The understanding that may lead to a publishable paper is much to be preferred to the understanding that leads to a useful machine. "But I say unto you, that every idle word that men shall speak, they shall give account thereof in the day of judgment. For by thy words thou shalt be justified, and by thy words thou shalt be condemned."†

Is it the case that our words here this afternoon are idle? Can we say anything true and useful in generalization about Pattern Recognition? Are there any broad statements that have any chance of being helpful to someone building a better machine? I hope there are.

"How much better is it to get wisdom than gold! And to get understanding rather to be chosen than silver."‡

What are our horizons? Have we explored so much? Mr. Heasly on Monday wondered if there were any horizons left. I suggest we've only barely reached where we are now, let alone anywhere else. Can I buy a print reader for a computer the way I can buy an office copying machine? No. For a quarter of a million dollars and a year and a half—perhaps—but to me a year and a half is exactly on the horizon.

Furthermore, any operationally useful system today only works on a very limited set of fonts, preferably one that it has been given. Some are all right: but myself, I cannot read the digits selected by the American Banking Association—and I hope the machine can. At any rate, I'm happy to know who they think important.

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*Operated with support from the U. S. Army, Navy and Air Force.
†Matthew, 12:36, 37
‡Proverbs, 16:16

There are several long-range goals visible in this field. To some of us, Optical Character Recognition is a step, and but a small step, to larger problems of pattern recognition, and perhaps towards artificial intelligence. To some of us the chief effect of OCR is to boost the price of certain stocks, and so on.

But, rationally, we all have several goals, and balancing them is one of the things that makes life fun. Our technology is surely going to have print readers, and surely going to find uses for them that we do not dream of. We can derive lessons from our trials.

Implicit in all the papers presented here has been the notion of features. That is, the characters by themselves are inadequate or inappropriate as direct inputs. For some schemes, simple easy features, like the tail on the Q, may be very useful. In such a case, we may refer to the Cinderella technique. The Prince, intoxicated with love, could remember merely that his true love fitted a certain glass slipper; (actually it was fur—"glass" is a mistranslation from the French). One would think he might have paid more attention to more valuable features than shoe size. No mind. Would that each letter were a Q with a distinctive tail!

One obvious next step after Cinderella is the *true love* technique. There is an old English folk song that goes:

How shall I my true love know
From another one?
By his cockle hat and staff
And his sandal shoon.

That is, by the logical conjunction of *several* features.

Another logical extension seems clearly desirable to the thinking man. Somehow our filtering techniques should deal with the Whole Woman. As a first step we can use overlapping or matching techniques. Here we refer to the *morning after* process. To recognize the girl the morning after, verify that she can exactly match the contour left in the sheets. Normalizing consists mostly of moving either the girl or the bed for Registration. This technique is not very sophisticated.

A step up, therefore, are schemes that allow that some parts are more valuable than other parts; we shall elaborate on the Whole Girl theme.

A certain king long ago, feeling desirous of providing his subjects with a son and heir, summoned his grand vizier. "Go out among all the peoples of the world and bring me the fairest and the wisest and the most amiable woman in all the world." "Do you mean three women, sire?" replied the vizier, "Or shall I maximize beauty and wisdom and amiability simultaneously?" "Hum." said his majesty. "Tell me how I may know her," said the grand vizier humbly. "Well," said the king thoughtfully, "There's no simple single thing." (Here note the first step to wisdom.) "Go thou, therefore," said the king, "and summon before thee the hundred fairest maids there are, even as at Atlantic City. From them select those excelling in wisdom, discarding the rest to lesser courtiers. From the elite selected, choose the most amiable. Go quickly; be back ASAP."

The grand vizier returned quickly (per diem was not very high those days) and went into the Royal Presence. "Sire," he said, "I have fulfilled the task—and even more. I took the one hundred fairest maids, and selected therefrom the wisest, and from these the most amiable, even as you suggested. Yet I thought the winner not enormously amiable, even rather much of a shrew. Then I selected the hundred most amiable maidens, and from them the fairest, and from these the wisest. In short, your majesty, with three descriptors to make permutations from among, I made three factorial selections; and Lo!, there are six maidens without the door awaiting thy pleasure."

The king, wiser himself beyond his age, and ours, too, for that matter, stroked his beard. The grand vizier added hopefully, "Perhaps your majesty prefers beauty to wisdom ... ?" "Not so," said the king, "both are important. Beauty and wisdom and amiability must be evaluated in parallel. Decision trees are not for me."

"Sire," said the vizier, "how shall we then proceed?" "You had better", said the king sternly, "get a grant and run a pilot study. Meanwhile, select the fairest maid of all and bring her to me." The vizier departed and returned. "Sire, none was perfectly fair, but this maid was nearest. It is true that she lacks one breast, the left one, but the next most fair lacked two toes, and two is greater than one."

At this, such a rebuke fell on his ears from the wrathful king that he retired for the day. For the king had learnt, even as we have learnt, of the desirability of weighted area scanning techniques. But the next day the king repented. "Here is a list of features, each perfect. Correlate them all on all women. I bought these features from a research institute abroad. Take due care that toes do not get rated too highly."

But, alas, that quest was as ill-fated as the rest. For while the face of Elizabeth Taylor is beauty as a face, yet placed on the body of Brigitte Bardot, a certain incongruity is apparent even to an untutored eye.

"Friend," said the king wearily to the grand vizier, "let's be sensible about this. I don't want a perfect fit. Just the best there is." "Verily," replied the grand vizier, "*now* you're thinking like a man!" "Sire," he added, "mayhap the fault is mine in that I do not sufficiently appreciate your taste. Styles change, your majesty. And even for yourself one perfect maid might not be perfect forever. Could I but learn to evaluate them as you do ...".

"You're getting a little close to the bone, friend," said the king thoughtfully. The vizier went on, "Permit me to select according to my description the three most perfect maidens *I* can find. They will be far from your majesty's taste, of course, but by the preference of your majesty for one over the other two I shall know how to amend my description, which shall consist of many features, each appropriately weighted. Then, according to the amended description, I can choose three more, among whom your dalliances may select another preference."

The king murmured, "Perchance this process could go on for some time. Still, that is not *altogether* bad. There is much to be said for learning and adaptation." And he gave his servant a bag of gold, and first choice among the discards.

It cannot be said that even this was wholly successful. One day, the king took the vizier aside. "Friend, what weight do you assign to ..." and he continued in whispers. "None, your majesty," gasped the vizier, "it's not even in my description." "Well, don't you think you had better put it there? Perhaps it ought to have considerable weight." "It shall be done at once."

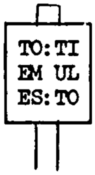
One day a few happy years later, the king, surrounded by his court, including his current favorite and numerous progeny, received an invitation to visit a cousin in a far Northern country; they set off. The vacation was ideal, and was marred only by the fact that the current queen, though nigh perfect in the palace, was no ball of fire on the ski slopes. So much so, that the king took his pleasure with a little blond Nordic type.

"Sire, she will be little acceptable back home," muttered the grand vizier, in a rare moment of frankness. "Don't I know it," said the king, "but we have shown the importance of CONTEXT."

And the king and his faithful servant rose from experience to wisdom to an old age blessed with contentment and delight. And here we leave our parable.

For people and machines are very different. We all readily admit that computers cannot read as well as we, but our own peculiar idiosyncracies are not well appreciated. Computers can work very fast, but not subtly, we say. They can deal with whole dictionaries, but without sophistication.

My friend Warren McCulloch, travelling through the back woods of Missouri, saw this sign next to a diner on a post stuck in the ground: What could it mean? Toti Emul Esto? A secret message?—the CIA?—the hobo code?—Swahili? It must be very deep and very subtle. And yet we have a simple program at Lincoln Laboratory that decodes that in milliseconds. The program is called Degarbler, and it is supposed to correct text that has been corrupted in a certain way. It looks for words; when it doesn't find them, it tries plausible



corrections. Actually it works in a rather simple way, though not obviously. Of course in this case, not even any corrections are needed. The sign says TO TIE MULES TO.

I suppose I am carrying thieves to Baghdad in bestowing this deep truth, that men and machines differ, on this audience. The flexibility and learning that men show, we must learn to understand, or at least simulate.

The vizier, you remember, said a very insightful thing when he said that he would know how to amend his description knowing the king's preferences. How can we be sure that the descriptions we may use are adequate? On the one hand you may remember that the vizier forgot to include a key feature entirely.

And on the other hand, he had to be reasonably parsimonious in his descriptions. He did not treat each square centimeter of a maiden as an independent variable—it would have been very tedious to optimize each of the 17,000 odd square centimeters of the ideal and discover that each should be individually without blemish. No, it is far easier and much quicker for optimizing if we put on our spec. list: Item 42 - "Save for the aforementioned singular points and regions and certain exceptions listed below, all the epidermis shall be substantially without blemish and capable of a nice tan and notwithstanding ... "

Someone remarked that every technique of optical character recognition was equivalent to a mask or masks. I think this is not so.

In my little parable I forgot to mention that this king was very fussy about the development of limbs. The vizier soon found that of ideal legs he had a large catalog, or, as we might say, a set of masks. Even so might some large random net! But the vizier noticed in his travail a curious thing. A certain maid A had a left leg very similar to that of the Queen of Sheba who was, as it happened, unavailable; coincidentally, her right leg closely approximated that of the goddess Aphrodite. Astonishing to say, this paragon was speedily eliminated by the king, who knew, though he could not say how or why, that in legs and elsewhere symmetry is much to be preferred to individual and separate exquisiteness.

I do not easily conceive of a set of masks which weights symmetry of an *object*. But if we examine the description we might soon find as a valid and valuable feature that the description of the left should be a very simple transformation of the description of the right.

I will not now go further into this point, that for advanced pattern recognition it might be profitable to recognize different levels of description. Many have proposed that new features be generated by binary combinations of old ones; well and good, if binary combinations work well.

After seeing a vision Friar Masseo, a confrere of St. Francis' (I quote): "remained filled with such grace of the yearned-for virtue of humility, and of the light of God, that from thenceforth he was evermore blithe of heart. And many times he made a joyous sound like the cooing of a dove - 'Coo Coo Coo' - and with glad countenance and jocund heart he dwelt thus in contemplation; and withal, being grown most humble, he deemed himself the least of men in the world. Being asked by Friar James of Falterone wherefore he changed not his note in these his jubilations, he answered with great joyfulness, that when we find full contentment in one song there is no need to change the tune."

Supposing we do have to change the tune, what then? While the answer must be "I don't know," I would not spatter my music paper with paint to discover new tunes. No more would I hope to find new mathematical theorems by spilling a box of mathematical type on the floor. Only in the last resort should we return to complete randomness as a way of building new features out of the atomic inputs.

One of the flyers given out at this Symposium claims that it "employs a completely new concept in the recording of information" and that it "applies an entirely new and unique approach to Optical Character Recognition."

I think that new concepts, alas!, are rarer than that. The words of the Preacher, the son of David, being in Jerusalem: Vanity of vanities, saith the preacher, vanity of vanities; all is vanity ... The wind goeth toward the south and turneth about unto the north; it whirleth about continually and the wind returneth again according to his circuits ... The thing that hath been, it is that which shall be; and that which is done is that which shall be done; and there is no new thing under the sun.

We have all the *concepts* we need. What we have to do now is to practice with them and evaluate them and apply them usefully.

I shall not here elaborate on the possible uses of OCR; but if we ever answer the question, "Where are we going?", it is worthwhile to wonder what we are going to do when we get there. To encourage meditation, here is another sample from the Little Flowers of St. Francis:

"Whence, appearing to one of his fellows too intent on study ..., he reproved and prohibited him, and ordered him that he should ... tread the path of humility and simplicity. [For] blessed Francis grieved greatly if any one, neglecting virtue, sought after the science which puffeth up ... For he was wont to say, 'My brethren who are led by desire of learning shall find their hands empty in the day of tribulation. I would therefore, that they be rather strengthened in virtues, that when the time of tribulation shall come they shall have the Lord with them in their straits. For a time of tribulation is to come, when books shall be useful for nothing and shall be thrown in windows and cupboards.'"