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April 08, 2007 Andrej Bauer General, Tutorial Cantor's famous theorem states that the cardinality of a $P(A)$ powerset is greater than the cardinality of A. There are several equivalent formulations, and what I want to consider is Theorem (Cantor): There is no on the map $A \to P(A)$. In this post I would like to analyze the usual proof of Cantor's theorem and present an intuitive reformulation that has applications outside the set theory. Everything that is written here is quite easy and far from being new, but in my opinion still interesting enough to be presented to a wider audience. If we open a book on set theory, we will find a proof of Cantor theorem that explicitly shows that for each $e map: A \to P(A)$ there is a subset of A outside its image, namely $$S = \lbrace x \in A \mid x ot\in and(x) \rbrace$$ If we had $S = and(y)$ for some $y \in A$ would follow both that y is and is not a S item. A first observation is that this is a constructive test, from which the Cantor theorem also holds in the theory of intuitive sets. But how wide is the scope of the theorem really? We rework as abstract as possible, to give it a wider applicability. First we replace the $P(A)$ powerset with the Ω^A set of functions where Ω is the set of truth values. In the case of classical logic $\Omega = \lbrace 0.1 \rbrace$ but there is no need to rely on this fact. We prefer to think about the general situation where the truth values correspond to subsets of the singleton set $\lbrace 0 \rbrace$, so that $\Omega = P(\lbrace 0 \rbrace)$. The bijection between $P(A)$ and Ω^A is therefore only the usual one between subsets and their maps characteristics: a subset $S subseteq A$ corresponds to the map $\chi_S(x) = \lbrace u \in \lbrace 0 \rbrace \mid x \in S\rbrace $, while a map $\chi: A \to \Omega$ corresponds to the subset $\lbrace x \in A \mid 0 \in \chi(x)\rbrace $. The logical denial $\lnot$ can be seen as a $N map: \Omega \to \Omega$ defined by $N(p) = \lbrace u \in \lbrace 0 \rbrace \mid 0 ot\in p\rbrace $. Note that N does not have a fixed point, because if there were $p \in \Omega$ such that $N(p) =p$ then we would both have $0 \in p$ and $0 ot\in p$. Now our test reads as follows: Suppose we have a $e map: A \to \Omega^A$. Consider the map $s: A \to \Omega$ defined by $s(x) = N (e(x)(x))))$. If there were $y \in A$ such that $s = and(y)$, we would have $e(y)(y) = s(y) = N(e(y)(y)))))))))$, a contradiction. So e is not on. QED, how's it better than we had before? It gives us the opportunity to think about the positive aspects of the situation: If e were up, then $\ Omega$ could not have an endomap without fixed points. Since nothing in the test is based specifically on Ω being the set of thruth values we can replace it with a general set to get:(Lawvere): If there is a $e map: At B^A$ then every $f: B \to B$ has a fixed point. We already know how to demonstrateConsider the $ s map: a $ b defined by $ s (x) = f (e (x) (x) $. because $ and $ is above, there is $ y \ in a $ such that $ and (y) = s $. then we have $ and (y) (y) = s (y) = f (e (y) (y) (y) $) and (y) (y) $ is a fixed point. Theorem of the singer is a corollary of the lawvere theorem with $b = \ omega $ and the observation of the negation does not have a fixed point. now consider the lawvere's theorem in isolation and how it would be committed to demonstrating it, perhaps something like this: â € "How can I have such on map $ and: a \ to b ^ to $? definitely $b $ can not have too many items, in fact, this can only happen if $b is a singleton or empty. I can see the theorem of the labs to be of course true but it is garbage because it contains only trivial cases. »There is a mistake in the last sentence: As we will see shortly, the lawvere theorem is true in interesting cases, but you (imaginary mathematician, not readers of this blog ...) can only imagine it in trivial cases because you have not worried about looking outside the narrow scope of the set-theoretical. theorem of the lawvere is a positive reformulation of the diagonalization makeup that is in the heart of the theorem of the singer. can be formulated in any closed category of Cartesian and its test uses only an equivalent reasoning with a first-order logic module. We should expect it to have a much wider applicability than the singer's theorem. In fact, immediately we see that other well-known tests by diagonalization are corollary, for example: the set of sequences of numbers $ \ mathbb {n} \ to \ mathbb {n} $ is not numberable because the successor's operation does not have a fixed point. there is no continuous closing $\ mathbb {r} a c (\ mathbb {r,}\ mathbb {r)} $ from the real line on the space of banach of continuous real functions, equipped with the compact-open topology, because the real map $ x \ mapsto x + 1 $ is continuous and has no fixed points. More interesting, there are also positive consequences of the theorem of law: to counter the second case above, we ask if there is a continuous closing from $ \ mathbb {r} $ on $ c (\ mathbb {r,} [0.1])) $, the space of the real continuous functions taking values on the closed range and equipped with the sup metric. If there is such a map, it follows that the closed range has fixed-point property, and also that each cube $ [0.1] ^ n $ also has fixed-point property (exercise.) so this could be a nice way to prove the theorem of the brouwer fixed point, and even if it doesn't work, it's a good idea that will make you think of space filling curves for a while. in effective topos c.e. Sets are represented as maps $ \ sigma ^ \ mathbb {n} $ where $ \ sigma $ is set of semi-decidable truth values. because there is an effective enumeration of c.e. set, in the effective topos there is one on map $ w: \ mathbb {n} \ to \ sigma ^{n} $, which tells us immediately that $\ sigma $ has fixed-point property, and so does $\ Sigma ^\ mathbb {n} $ because it is isomorph a aSo we get a theorem in the theory of Computability by stating that each enumeration operator has a fixed point. Finally, let me comment on Paul Stadtmann's question on the list of FOM stations. He asks if the axiom of the separation (a.k.a. The axiom subset) is necessary to demonstrate the singer's theorem. If we are working only in the theory of the Straight Set, limited separation has certainly been sufficient. (This is the form of separation in which the defined predicate only has limited quantifiers of the module $ forall X in a $ and $ exists X in $, but none of the module $ forall x $ and $ exists x $.) However, limited separation is necessary only to establish a general fact on the sets universe, ie forms a Cartesian closed category. After the laboratory theorem enters and gets the job. So I would say that the separation is not used in an essential way here (for example, topos theory axiomatizes the exponentials directly and therefore the separation is not necessary at all). Each set is smaller than its energy set for other theorems that lead the name of the singer, see the singer's theorem (disambiguation). The cardinality of the set {x, y, z}, is three, while there are eight elements in its energy set (3 \ Aleph _ {0}}. Theorem is nominated for German mathematician GeorgWho declared it for the first time and proved it at the end of the 19th century. The cantor's theorem had immediate and important consequences for the philosophy of mathematics. For example, by iteratively taking the power set of an infinite set and applying the cantor theorem, we get an infinite hierarchy of infinite cardinals, each one strictly larger than the one before it. Consequently, the theorem implies that there is no larger cardinal number (colloquium, "there is no greater infinity"). The subject of the singer's rehearsal is elegant and extraordinarily simple. The complete test is presented below, with detailed explanations to follow. Theorem (Cantor) Ã¢â'¬Å Let f { displaystyle f} be a map from Set A { displayStyle A} with its power set P (A) { displaystyle { mathcal {p}} (A)}. So f: A Ã¢â'¬â"¢ P (A) {DisplayStyle F: A Ã¢â'¬â"¢s Mathcal {p}} (A)} is not Surievetive. Consequently, the card Â¡(a)

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