INFORMATIVNI RAD
INFORMATIVE ARTICLE

NANOTERMINATOR – ALAT ZUBARA BUDUĆNOSTI?

NANOTERMINATOR- THE TOOLS OF FUTURE DENTIST?

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Kratak sadržaj

Sve je bliže doba kada će nanokompjuteri početi da se primenjuju u stomatologiji. Biće to svakako revolucionarna promena, ali svako dobro nosi i svoje zlo. Nanoroboti napravljeni sa greškom, namerno ili slučajno, mogu da umesto pomoći ugroze ljudsko zdravlje. U radu se ukazuje na neke mogućnosti za rešavanje ovih nedostataka.

Ključne reči: *nanoterminator, zubar budućnosti*

Summary

An epoch is nearer and nearer when nanocomputers will start being applied in dentistry. It will be of course a revolutionary change, but not without the consequences. Nanorobots created with mistakes, accidental or intentional, may endanger people's health instead of helping them. In the article we point to some of the possibilities for the solution of this problem.

Key words*: nanoterminator, future dentist*

Prošlo je već nekoliko decenija od prvih nagoveštaja da bi se na nivou molekula i atoma – na nanonivou, mogli izgraditi roboti koji bi umesto nas vršili određene funkcije, i od prvobitne neverice sve smo bliži shvatanju da ostvarenje ovog cilja nije previše daleko. Stoga se već razmatraju raznovrsne mogućnosti primene ovakvih robota, što je u suštini ograničeno samo našom maštom. Kako u ostalim granama nauke tako se i u medicini oni mogu primenjivati, a za nas je posebno zanimljiva primena u zubarstvu. Pošto je polje rada na kom bi trebalo nanoroboti da rade za njih relativno veliko, s obzirom na veličinu samih robota, a takođe i obim poslova, smatra se da bi u ovim radovima trebalo da učestvuje veliki broj (hiljade pa i milioni) nanorobota.

Naravno, svako dobro ima svoje zlo, pa je cilj ovog rada da ukaže na jedan od problema, sa mogućnostima rešavanja, ali i prevencije.

A few decades have passed from the first announcement that on the molecular and atom level i.e. on the nanolevel, it is possible to make robots which would, instead of us, do some jobs. From the first disbelief, now we are nearer and nearer to comprehension that realization of this target is not so far away. Therefore, there appeared various possibilities for the application of this kind of robots, and they are in essence limited only by our imagination. Robots can be applied in many branches of science as well as in medicine, but for us the most interesting application is in dentistry. As the working field in which nanorobots should work is relatively large for them, and taking into consideration the largeness of robots themselves, and also the volume of works, it is consider that in this works the large number (thousands and even millions) of nanorobots should take part.

Of course, nothing is perfect, and the target of this work is to point out to one of the prob-

Bez obzira na preciznost sa kojom nanoroboti budu izrađeni njihova primena se mora vršiti sa određenim oprezom, jer je teško kontrolisati da li među hiljadama i milionima ovih robota ima i onih sa greškama, pa bi primena ovakvih robota mogla izazvati teške posledice, čime bi se anulirala dobijena korist.

Greške ovakve vrste se dešavaju i u živom organizmu, ali normalno u organizmu postoje mehanizmi koji treba da neutrališu greške nastale pri razmnožavanju živih ćelija eliminisanjem ćelija koje ne zadovoljavaju stroge kriterijume kvaliteta. Ukoliko ovi mehanizmi otkažu, kao što je to slučaj kod malignih oboljenja, rezultat je često fatalan završetak.

Pitanje je šta će se desiti ako se neki od nanorobota otmu kontroli, npr. oni koji su namenjeni anesteziranju zubne pulpe (bilo zbog kvara ili greške u njima, ili kvara u kompjuteru koji kontroliše njihovo kretanje ukoliko su kontrolisani na taj način) i pređu u krvotok, a zatim dospeju u neki od vitalnih centara, kao što su npr. centri za disanje i srčani rad u produženoj moždini, Hisov snop u srcu i slično i tu prekinu tok nervnih impulsa. Posledice bi mogle da budu katastrofalne. Nanoroboti namenjeni proširivanju ili sužavanju dentinskih kanalića mogli bi to isto da urade i na nekom drugom, neželjenom mestu. Neispravni nanoroboti bi umesto patogenih bakterija mogli da razaraju saprofite koji imaju korisnu ulogu u organizmu, a umesto da pomažu lečenje neke bolesti usporavali bi ga i otežavali.

Materijali od kojih se nanoroboti izrađuju treba da budu biokompatibilni[1,2] i da ne izazivaju alergijske reakcije. Nažalost, ljudski organizam je nepredvidiv, pa ima i alergija na sopstvene, u organizmu proizvedene materije, što se manifestuje teškim poremećajima, a čak postoje i alergije na antihistaminike. Kako u tom slučaju eliminisati iz organizma robote pre programiranog vremena?

Ne treba se zavaravati tvrdnjama onih koji imaju nameru da proizvode nanokompjutere da su, s obzirom da je sistem proizvodnje nanorobota zasnovan na principima koji se razlikuju od klasične proizvodnje, svi roboti dobijeni procesom autoreprodukcije identični, pa ne sme da postoji greška u njima. Mora se poći od činjenice da kao i u svakoj vrsti proizvodnje postoji konkurencija koja će se truditi da proizvodnju konkurentske firme poremeti ili oteža.

lems, with the possibility to solve them, but also prevention.

In spite of the precision with which nanorobots will be made their application must be with certain reserve, because it is difficult to control if a few of thousands and millions of nanorobots may have mistakes, so the application of that kind of robots may provoke heavy consequences, that would annul the profit.

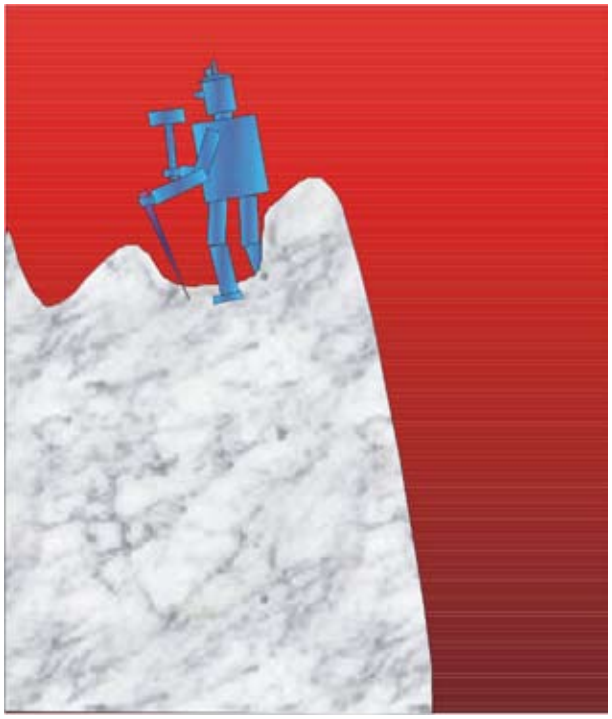
Mistakes of the same kind also happen in the living body, but in the body there exists a mechanism which should neutralize mistakes which occurred at multiplying of the living cells by eliminating cells which do not satisfy the strict quality criteria. If these mechanisms break down, as is the case with malignant diseases, the result is a fatal end.

It is a question what will happen if some of nanorobots free themselves from control, for example those intended for anesthetizing the dental pulp (because of the damage or error in them, or in the computer controlling their moving, if they are controlled in that manner), and pass in the blood, and then arrive in one of the vital centers, for example respiration center or heart working center in medulla oblongata, or conduct bundle in the heart and discontinue the current of nervous impulses. Consequences may be catastrophic. Nanorobots intended to widen or to narrow the dental tubules may do the same thing on the other, unwanted place. Incorrect nanorobots can destroy nonpathogenic bacterias which have a useful role in the body instead of pathogenic bacterias, and instead of supporting treatment of some disease, they decelerate and make it difficult.

Materials from which nanorobots are made should be biocompatible[1,2] and not provoke allergic reactions. To our regret, human body is unpredictable, and has allergic reactions to its own substances, which is manifested by heavy disturbances, and even allergies on antihistamines. How, in this case, to eliminate nanorobots from the body earlier than the programmed time is up?

We should not be misled by the claim of those that intend to produce nanocomputers that, taking into consideration that the system of production of nanorobots is established on the principles which are different from classic production, all robots made by self reproduction process are identical, and that there should not exist any error in them. It proceeds from the

Posebno zainteresovani za nanorobote su i vojni stručnjaci[3,4,5,6], te će neki od nanorobota biti namerno pravljeni sa posebnim funkcijama, npr. sa ciljem da parališu ili uništavaju vitalne centre, slično bojnim otrovima, u kom slučaju bi se verovatno i aplikovali na sličan način (u vidu magle, gasa, kiše, ubacivanjem u vodovod, hranu...). Neki od njih bi se koristili za namerno postepeno narušavanje ljudskog zdravlja, npr. oštećivanje zuba (Slika 1). Pearson, Coombs,



Slika 1. Neki od nanorobota će biti korišćeni za namerno narušavanje ljudskog zdravlja
Figure 1. Some of nanorobots will be utilized for intentional disturbance of peoples health

Robinson i saradnici ukazuju da ukoliko u pulpi u toku 30-45 sekundi dođe do povećanja temperature za ~6.5-10º C može doći do stalnog oštećenja pulpe, na šta ukazuje i Freitas kada govori o mogućnosti oštećenja pulpe dejstvom nanorobota.[7] Pored dejstva na pulpu moguća su i oštećenja čvrstih tkiva suprotno procesu terapije zubnog karijesa. Jasno je da vojnici sa lošim zubima ne mogu dobro da se hrane, te će i njihova borbena sposobnost biti smanjena, pogotovo ako su oštećenja zuba povezana sa bolovima u zubima, a teško je optužiti neprijatelja za tu vrstu agresije. Policija bi mogla da ih primenjuje za obuzdavanje kriminalaca, umesto da ih drže u zatvorima, ali verovatno bi pored kriminalaca bili primenjivani i na nekim drugim osobama. Tajne službe će oberučke

fact that in every production there exists competition, which will make an effort to disturb or make production of competition firm more difficult.

Nanorobots are especially interesting for military experts[3,4,5,6], and some of nanorobots will intentionally be produced with special functions, for example with a goal to paralyze or destroy vitality centers, similarly to chemical warfare agents, in which case they will probably be applied in a similar way (in the form of fog, gas, rain, by throwing into water supply, food…). Some of them will be utilized for intentional and gradual disturbance of people's health, for example to damage teeth (Figure 1). Pearson, Combs, Robinson and fellows point out that an increase of ~6.5-10º C in tooth pulp temperature for > 30-45 seconds can permanently damage the pulp. Freitas also point out to that when writing about the possibility of damaging the pulp due to overactive dental nanorobots. [7] In addition to the effect on tooth pulp, it is also possible to damage hard tissues, opposite to the process of dental caries therapy.

It is obvious that soldiers with bad teeth are not able to consume food well, and so their combat readiness will be reduced, especially if tooth damage is combined with pains in teeth. It is of course difficult to accuse the enemy for this form of aggression. Police should utilize them to control criminals, instead of holding them in prisons, but probably in addition to criminals they would apply them to some other persons. Intelligence departments, terrorists too, will welcome the application of invisible agents.[8]

Writing about living in the new millenium Ilić states: "Atomic arms will still be present, but nanotehnology will make it possible to create even more destructive arms.[9] Other autors assembled with him because"… nano-scopic particles have the potential of running riot in the environment (and our bodies)".[10]

Finally, as in the use of a classic medicine, the accidental mistakes in prescribing, a dose, or in time of the application of the nanorobots, may cause some disturbance.[11]

For that reason ecologists ask can the nanobots deliver the drug with acceptable accuracy? What „collateral damage" could the nanobots do to the body while delivering the drug and what happens to nanoparticles or nanobots after they've accomplished their mission? Are they excreted, and if so, what is their activity in the

prihvatiti primenu nevidljivih agenata, teroristi takođe.[8]

Pišući o životu u novom milenijumu Ilić navodi: Atomsko oružje će i dalje biti prisutno, ali nanotehnologija će omogućiti pravljenje čak i mnogo destruktivnijeg oružja.[9] I drugi autori se slažu sa njim jer "…nanoskopske čestice imaju potencijal da izazovu metež u okruženju (i našem telu)".[10]

Najzad, kao i kod primene klasičnih lekova slučajne greške u propisivanju, doziranju i vremenu primene nanorobota mogu izazvati određene poremećaje.[11]

Zato se ekolozi pitaju mogu li nanoroboti osloboditi lekove sa prihvatljivom preciznošću? Koju kolateralnu štetu mogu nanoroboti učiniti u telu dok oslobađaju lekove i šta se dešava sa nanočesticama nanorobota pošto oni izvrše svoju misiju ? Da li su oni izlučeni, a ako je tako, šta je njihova aktivnost u okolini. Koje posledice tako mogu imati?[12]

Freitas navodi:«...da će nanodoktori 21. veka želeti da uklone terapeutske nanorobote iz pacijentovog tela čim nanouređaji završe posao. Tako će postojati mala opasnost da se stari nanoroboti polome, ili pokvare, ili prouzrokuju nešto neugodno za pacijenta po završetku tretmana bolesti ili traumatskog stanja. Nadalje, nanoroboti će biti dizajnirani sa visokim stepenom redundancije da osiguraju operativne i sigurnosne performanse, dalje redukujući medicinski rizik.«[13]

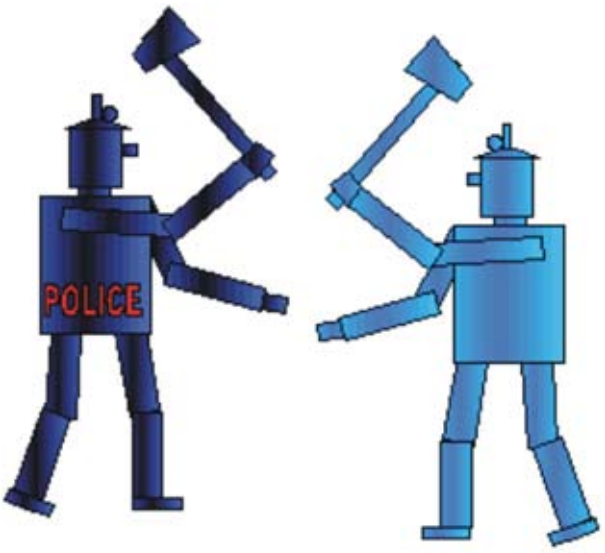
Možda bi za ovakve prilike trebalo konstruisati neke "nanoterminatore" – ubice nanorobota (Slika 2), koji bi po organizmu tražili i uništavali neposlušne i "poludele" nanorobote. Ali moramo reći i sledeće: šta ako i sami nanoterminatori imaju grešku, pa umesto nanorobota počnu da love normalne ljudske ćelije?

Poseban problem predstavlja izrada nanoterminatora, jer bi oni morali biti sposobni da savladaju nanorobote. Ako ih učinimo većim od nanorobota, ne bi bili u stanju da prođu kroz uske prolaze i dospeju na sva mesta gde se nanoroboti kriju, ili bi to činili znatno sporije od njih (polazimo od toga da normalna tkiva ne smeju biti oštećena), sem ako ne bi mogli da se podele na više manjih delova, a zatim ponovo spoje u celinu. Dakle nanoterminator bi morao da bude spretniji, inteligentniji ili od čvršćeg materijala, ili pak snabdeven nekom materijom koja izaziva razaranje nanorobota. Problem je npr. kako savladati nanorobota kog smo zbog prirode poenvironment? What consequences could that have? [12]

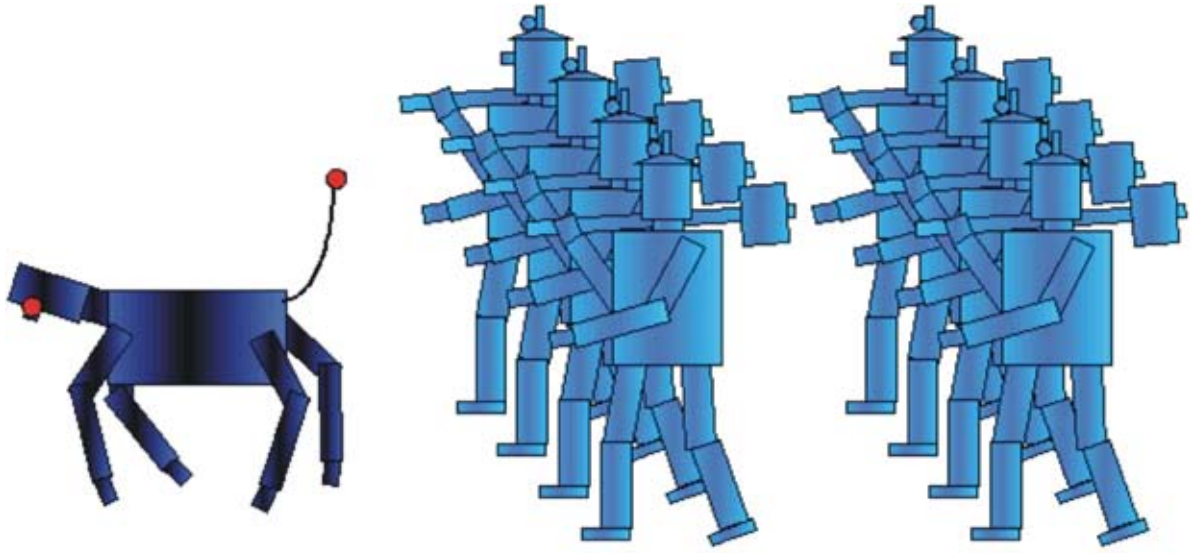
Freitas quote: „Following most simple treatments, nanodoctors of the 21st century will want to remove their therapeutic nanorobots from the patient's body as soon as the nanodevices have finished the job. So there will be little danger of „old nanorobots" breaking down or malfunctioning, or causing something unpleasant to happen to the patient after the original disease or traumatic condition has been treated. Additionally, nanorobots will be designed with a high level of redundancy to ensure fail-operational and fail-safe performance, further reducing the medical risk".[13]

Maybe for this kind of occasion it is necessary to construct some "nanoterminators" – killers of nanorobots (Figure 2), which will search in body and destroy disobedient and "crazy" nanorobots. But, we must say something else: What if nanoterminators themselves have mistakes, and instead of nanorobots begin destroying normal body cells?

A special problem is production of nanoterminators, because they must be able to defeat nanorobots. If we made them bigger than nanorobots they would not be able to pass through narrow passages and to arrive in all places where nanorobots hide, or they would do it considerably slower than them (we assume that normal tissues must not be damaged), except if they can divide, and connect together after that again. Therefore nanoterminator must be cleverer, more intelligent or made from harder



Slika 2. Nanoterminatori mogu uništavati nepoželjne nanorobote
Figure 2. Nanoterminators may killing nonwanted nanorobots



Slika 3. „Roboti vodiči" bi vodili „robote radnike"
Figure 3. „Robot-guides" would guide „robot-workers"

sla naoružali dijamantskom bušilicom, kada znamo da je dijamant najtvrđi nama poznati materijal, otporan na sve nama poznate hemijske materije. Istina je da dijamant sagoreva u struji kiseonika na visokoj temperaturi, ali zar ne bismo time uništili i okolna tkiva.

Dobro je da svaki od nanorobota bude pod direktnom kontrolom centralnog kompjutera koji bi vodio računa o tome da li neki od nanorobota pravi probleme (slično antivirusnim programima koji neprekidno kontrolišu stanje pojedinih fajlova na disku kompjutera) i odmah intervenisao isključujući ih iz funkcije. Naravno ako se i on sam ne pokvari, bilo zbog greške u elektronici ili operacionom sistemu (setimo se čuvenih Windows-ovih plavih ekrana). Pored ovog može se javiti i problem međusobne komunikacije centralnog kompjutera i nanokompjutera, a i sam nanokompjuter takođe može biti u kvaru.

Možda bi nanorobote trebalo izrađivati od materijala koji imaju ograničen vek trajanja (npr. nekoliko sati) posle čega bi se u organizmu, slično čokoladnim bombonama, raspadali na biološki inaktivne komponente, koje se mogu eliminisati ili metabolisati.

Druga mogućnost je da se sa njima odmah pošalju i nanoterminatori koji bi počeli sa uništavanjem nanorobota odmah po unošenu u organizam, te bi broj nanoterminatora bio prilagođen broju nanorobota i obimu posla koji treba izvršiti.

Najzad, možda bismo u same nanorobote mogli da ugradimo mehanizam za samouništenje, sličan apoptozi.

material then nanorobots, or they must have some substance which will provoke destruction of nanorobots. There is a problem, for example, how to defeat nanorobots which we supply with diamond drilling machine, when we know that diamond is the hardest substance known to us, resistant to all well-known chemicals. Really, diamond burns in oxygen current, at high temperature, but so we will destroy surrounding tissues too.

It is good that every nanorobot be in direct control from the central computer, which will take care if some of nanorobots make problems (similarly to antivirus programs which continuously control the status of single files on the computer disc) and immediately intervenes by disconnecting them from the function. Of course, if the computer itself is not damaged, because of the mistake in electronic or in operation system (remember well-known Windows blue screens). In addition to that problem of inetercommunication between the central computer and nanocomputers may appear, and the nanocomputer itself may be damaged.

Maybe nanorobots should be made from materials which have limited duration time (for example, a few hours). Afther that they are destroyed in the body, like a piece of candy, and decompose into biologically inactive components, which may be eliminated or metabolized.

Another possibility is immediately to send nanoterminators which will start destroying nanorobots immediately after the entry into the body. The number of nanoterminators must be

Pored ovog, da bi se sprečilo da nanoroboti nekontrolisano odu sa mesta na kom je predviđeno da rade, moguće je u memoriju "robota radnika" ugraditi samo onoliko podataka koliko je dovoljno za rad, ali ne i za kretanje, već bi se time bavila nekolicina drugih "robota vodiča" (Slika 3) koji bi (poput ovčarskih pasa koji ne jedu travu, niti daju mleko, ali nepogrešivo vode stado) vodili robote radnike do mesta na kome će raditi i obrnuto.

p.s. Zahvaljujući napretku nauke čovek je spoznao da nije monolitno biće, već je sazdan od niza znatno manjih delića, koji takođe imaju neke svoje delove, a ovi pak svoje. U našem organizmu, bez obzira što mi toga uglavnom nismo svesni, bilo kao paraziti ili saprofiti žive i neka druga živa bića, mnogo manja od nas – bakterije, rikecije, virusi, prioni… Ko zna koliko nivoa života postoji ispod onog koji smo u stanju da vidimo i shvatimo, a još teže bi nam bilo da shvatimo da tako nešto možda postoji i iznad nas i da je ceo naš beskrajni svemir možda samo trun u oku nekog džina.

Ako je već tako, možda ima živih bića i na nivou molekula i atoma, možda ne baš u onakvom obliku kakav mi zamišljamo i na kakav smo navikli. A zar ne bismo mogli da neka od tih bića pripitomimo, dresiramo ili pretvorimo u zombije koji bi bespogovorno izvršavali svako naše naređenje.

Setimo se da je u prirodi krvoločni vuk, pripitomljen naš najveći prijatelj.

adapted to number of nanorobots and to the volume of anticipated work.

Finally, perhaps we may build a mechanism for self-destruction in nanorobots, similarly to apoptosis.

In addition to this, to prevent nanorobots from incontrollably leaveing the working place, it is posible to put as many information as is enough for work in the memory of „robots-worker". Some other "robot-guides"(Figure 3) would be engaged for moving, and they would guide „ robot-workers" to working place and back (like the sheep dogs which don't eat grass, or give milk, but unerringly lead a flock of sheep).

p.s. Thanks to progres of science a man perceived that he is not a monolite entity, but is built from a large number of much smaller parts, which also have some parts, and so on. In our body, despite that we are not conscious of that, some other living parasite or inparasite entities, much smaller then us – bacteria, ricetias, viruses, prions…Who knows how many levels of life exist under that one which we are able to see or compehend, and it is even more difficult to comprehend that something perhaps exists above us, and that all our endless space is perhaps only a crumb in the eye of some giant.

If this is so, perhaps there are living entities on the molecule and atom levels, perhaps not in that form that we can imagine, and to which we are accustomed. And really, could we domesticate some of them, train or transform them into "zombies" which will obediently carry out every order.

Remember that the bloodthirsty wolf in nature has been domesticated as man's best friend.

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