CTNet: Technical Monograph on Architecture, Internal Dynamics, and Coherence Tensor

English technical translation

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OpenAI - technical synthesis from CTNet corpus provided by the user

Abstract

This document sets out CTNet architecture at its lowest technical level and fixes a unified formulation of its primitives, equations, internal topologies and computational consequences. The text does not describe a particular implementation nor a version numbering. Its object is CTNet architecture as a general class of system. The central architectural thesis is that the computation should not be understood as episodic rewriting of a dominant representation, but as governed evolution of a persistent state, reversible multiscale, topologically memorized, reweighted by coherence and only finally projected in local outputs. From that thesis, it develops a complete grammar of substrate, memory, regime, admissibility, charts, selector, Coherence Tensor, order object, stitching local-global and master transition equations.

The architecture is described in several strata. First, it fixes its primitives and the space of states. Then, it builds the reversible substrate through couplings additive, cardinal partition and multiradius mixture. It then formalizes the distributed topological memory, which does not grow by stacking slots but through increase of recoverable structure on an atlas of fractions. Against that background, it defines the regime as an internal control variable, the admissibility as native legalization of trajectories, the multi-chart selection as ecology of local readings and the projective output as disciplined appearance of a part of the whole. The core of the document is devoted to the Coherence Tensor: its form Diagonal metric plus low-rank correction, its reading of bidirectional consistency between cardinal halves, its version by branches, its transformation of structural information into dynamic mass, and the coincidence between the analytical part and the real part of the value. Finally, it collects design invariants, costs, complexity, inference implications, long-memory mechanism, taxonomy of degenerations and operational appendices with symbolic notation, pseudocode and compact equations.

The result is a closed monograph of CTNet computation space. Its objective is not to compare benchmarks nor to produce a historical narrative of the project. Its objective is to formulate precisely what CTNet, how it works each of its parts, why those parts cannot be reduced to one another and what computational economy emerges when all operate jointly.

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1. Purpose of the document and thesis

architectural

1.1. Object

CTNet defines here as a architecture of regime of computation, not as a list accidental of modules. A tratamiento puramente modular would be insuficiente because ocultaría the law common that organiza the whole. The rasgo strong of CTNet not is that contenga reversibilidad, memory, selection, coherence and order as parts yuxtapuestas, but that those parts are subordinadas to a same thesis: the computation valioso does not consist in destroy state for produce a output, but in preserve, transformar, fraccionar, legalize, enrutar and proyectar a background persistent of structure.

1.2. Strong thesis

The Strong thesis can escribirse of form seca. Sea a system that receives entradas, actualiza a state interno and emite a output. A architecture of representation episodic tenderá to identificar the act of computing with a rewriting dominant of the representation actual. CTNet, instead, identifies the act of computing with a transition governed of the persistent state. The output not agota the state, the memory not is a archivo external, the admissibility not is a poda ornamental, the selector not is a clasificador tardío and the coherence not is a penalty final. All those objetos are constitutivos of the step computational elementary.

1.3. Immediate consequence

The Immediate consequence is that CTNet not can evaluarse correctamente only with metrics of output. If the architecture is construida for preserve structure, distribuir memory, sustain multiple charts and convertir value structural into dynamic mass, then its economy interna not is agota in the error final of tarea. This is the motivo by the that the monograph is organiza by capas operatorias before that by resultados experimentales.

2. Primitives, variables and notation

2.1. Main variables

Usaremos the siguiente notation básica:

• xt RN Œd : entrada or state observable in the instante t. • zt RN Œd : persistent state or substrate interno in the instante t. • mt Rq : memory activa global. (i) (i)

• {mt }K i=1 , with mt Rq : fractions memoriales local.

• t : distribution of Dynamic regime. R

• at [0, 1]N Œd : compuerta of admissibility.

(k) • ct RN Œd : chart local k. • t K : distribution on charts. glob • oloc t and ot : order object local and global. • yt R N Œd : projective output. • Ht : funcional or Coherence Tensor.

2.2. Separation of planes

The architecture impone from the principio a separation strong between planes:

state output, memory archive, regime task, selector answer, order positional encoding.

This separation not is meramente conceptual. Each a of these variables is implements through operators distintos and no can be collapsed in other without loss architectural real.

2.3. Internal cardinal structure

The persistent state is descompone cardinalmente in two halves complementarias:

```
zt = [ut , pt ], ut , pt RN Œd/2 .
```

The descomposición u/p not is a partition arbitraria of the vector. Is the form minimal of alojar a bidirectional consistency between two charts of the same state. More adelante, the Coherence Tensor medirá precisamente the compatibility structural between these two halves.

2.4. Multiscale

The naturaleza multiscale of the substrate is represents by a familia of resoluciones local or radios of mixture,

```
R = {r1 , r2 , , rJ },
```

of modo that each transition elementary can reponderar information of vecindades distintas without reducir the state to a single scale effective.

3. The elementary unit of computation

3.1. From rewriting to governed transition

In CTNet the step computational elementary not is formulates as

```
ht+1 = f (ht , xt ),
```

but as a chain of operators that act on a background persistent. The form minimal of the step is:

```
zt = rev (zt , ut ),
at = TO(zt , t ), ztadm = at zt ,
mt+1 = M (ztadm , mt ),
t+1 = G(zt , mt+1 , t ),
```

adm

```
t = H(zt , mt+1 , t+1 ),
```

adm

```
zt+1 = (ztadm ; mt+1 , t+1 , t ),
```

(k)

```
t = S(zt+1 , mt+1 , t+1 ), ct = Pk (zt+1 , mt+1 , t+1 ),
```

(k)

```
yt = R({ct }K
k=1 , t ).
```

3.2. Reading of the equation

The reading strong of this chain is the siguiente. The substrate is transforms before of cualquier reading; that transformation is legalizada by the admissibility; the memory reentra in the transition and not only in the readout; the regime regula the modo same of the transition; the coherence determines how much value structural must have mass real; the charts are local readings of a background compartido; and the output is a projection composicional on those charts.

4. Reversible substrate and mixture

multiradius

4.1. Invertible router

The primer operador structural of the substrate is a Invertible router or permutation cardinal. Formalmente,

RN Œd RN Œd , 1

=

when the permutation is codifica as matriz ortogonal of permutation. Its function not is add expresividad by yes single, but romper couplings rígidos of coordenadas and redistribuir the state without loss of information.

4.2. Hyperradial kernel

CTNet usa a operador of mixture local on several radios. Sea z RBŒN ŒC and sea R = {r1 , , rJ }.

For each radio rj is consideran three desplazamientos local:

Lrj (z) = roll(z, rj), M (z) = z, Rrj (z) = roll(z, +rj).

Is aprende a control local on the combination of izquierda, centro and derecha:

j = softmax(j) ,

with it that the contribución of each radio is

Krj (z) = j,1 Lrj (z) + j,2 M (z) + j,3 Rrj (z).

The mixture whole is

K(z) = GELU(RMSNorm(J Krj (z))),

j=1

where is a factor of scale aprendible. The relevancia of this operation is double: introduces multiscale real and maintains the computation dentro of the same soporte espacial of the state.

4.3. Elementary reversible block

Sea x = [x1 , x2] with x1 , x2 RN Œd/2 . The Elementary reversible block is escribe as

y1 = x1 + F (x2), y2 = x2 + G(y1),

and = [y1 , y2].

The inversa exact is

x2 = y2 G(y1), x1 = y1 F (x2).

This esquema not necesita almacenar all the activaciones intermedias for reconstruir the state previo. The propiedad structural esencial is that the transition preserves suficiente information for impedir that each step is comporte as amputation irreversible of the historial.

4.4. Fractal latent coupling

CTNet introduces a dynamics latent interna on a mitad cardinal. Sea p a of the halves of the state. Defines a dynamics latent reversible composite by K steps of a block base:

Flat = (Fbase)K , 1

Flat = (Fbase

)K .

On that base is actualiza the other mitad cardinal:

u + lat Flat (p).

Then is applied the block reversible principal. This coupling performs two functions: densificar the relation between cardinal halves and aumentar the capacidad of preservation structural without destroy the invertibility of the whole.

4.5. Fractality

The palabra fractal not is usa here as ornamento metafórico. Designa the fact of that the same patrón of transition reversible and multiradius mixture can iterarse to several profundidades of the state. The substrate not is organiza as a single operation soberana, but as a pila of transitions compatibles that maintain the same law local.

5. State persistence and memory

of the past

5.1. The state is not identified with the output

The persistent state not is a buffer of output. Is the background on the that is realiza the work living of the computation. The fact of that the output is obtenga more tarde by projection implies that the system not is obligado to compactar all the work interno in a single canal visible.

5.2. Memory does not grow by slots

A propiedad central of CTNet is that the memory useful can aumentar without necesidad of aumentar the size bruto of the memory. The reason is that the memory not grows by stacking of copias, but through increase of recoverable structure on a same volumen latent. The system not almacena each instante as fotografía complete; preserves continuidad operator suficiente for reconstruir funcionalmente the all by atlas, by composition or by retardos.

5.3. Reversibility and memory of the past

The reversibilidad of the substrate implies that part of the past remains preservado in the structure of the presente. Not must confundirse this with a reproducción exact of all the historia. The thesis correct is more fina: the presente can preserve suficiente huella of the recorrido as for that the historia siga actuando causalmente on the transition actual.

6. Distributed topological memory

6.1. General idea

The memory of CTNet not is a cache external nor a archivo secuencial of slots. Is a atlas topological distributed. Sea the state zt RN Œd . Is divides in K fractions local,

(i)

zt = K zt ,

i=1

with tamaños posiblemente distintos but suma whole constante. Of each fraction is extracts a chart memorial local.

6.2. Local encoding

Each fraction is codifica by a operador local Ei and is combina with a latency base by token:

mt = Ei (zt) + mean(B(zt)).

(i) (i) (i)

Here B represents a encoding base by token. The finalidad of this suma is that the memory local not dependa only of the chart regional nor only of the average local, but of the conjunción of ambas.

6.3. Orthogonal rotations

Each chart local is rota by a operador almost ortogonal or explicitly ortogonal:

(i) (i)

mt = Qi mt , Qi Qi I.

These rotations cumplen two functions. First, prevent that distintas fractions is superpongan trivialmente in the same axis. Second, facilitan that each fraction toque the whole low a ángulo distinto without perder comparabilidad global.

6.4. Topology among fractions

The interaction between fractions is regula through a matriz of coupling learned

TO RKŒK , Aij 0, Aij = 1.

j

The feedback topological is obtained by

(i) (j)

mf b = K Aij mt .

j=1

Not is treats of a average neutro. The topology TO determines what fractions must influirse mutuamente and with what intensidad.

6.5. Injection of the whole

Together to the atlas local is computed a Abstract global of the state,

mglob

t = G(zt),

and then is combinan chart local, feedback topological and Abstract global:

(i) (i) (i)

mt = (1)mt + mf b ,

(i) (i)

mt = (1)mt + mglob

t .

6.6. Emergent global summary

The Abstract final not is simplemente the mean of the fractions nor the projection global inicial. Is obtained by mixture between the mean of the atlas and the Abstract global primario:

1 K (i)

mt = m + (1)mglob .

K i=1 t t

The memory global is, therefore, a reorganization distributed of the whole and not a chart soberana of the whole.

6.7. Token-wise reinjection

Each token receives simultaneously three sources memoriales: its latent base, the chart fraccional that le corresponde and the Abstract global. If ht,n is the token n, the memory reintegrada builds by

(i(n))

t,n = T (B(ht,n), mt , mt),

where T is a mezclador local and i(n) denota the fraction to the that the token pertenece.

6.8. Why it increases without increasing in size

The memory increases without aumentar of size because it that grows not is the number bruto of celdas, but the number of relaciones, charts, reconstrucciones and trajectories recuperables on the same soporte. Each new transition reorganizes the atlas and increases the value structural available. In vez of memory by accumulation linear of copias, CTNet obtains memory by densificación topological of the same volumen latent.

7. Dynamic regime

7.1. Regime as an internal control variable

the regime not is sinónimo of tarea. Is the variable that decides how must computarse a same tipo of state low conditions distintas. Formalmente,

t = G(zt , mt , t1 , ut).

Its output is a distribution on R regimes. The architecture not force a ruta single; produces a distribution that controla the resto of operators.

7.2. Slow context

the regime generates a slow context cslow t that acts as condensado of the dynamics reciente:

cslow

t = Cslow (pool(zt), mt , etask

t).

That contexto not is still output nor memory; is a variable intermedia of stabilization of the modo of computation.

7.3. Regime seed

From the state medio, the memory and the contexto exógeno is siembra a distribution inicial of regime:

seed

t = softmax(W[zt , mt , cslow

t]).

7.4. Segmental dynamics

For secuencias largas or states segmentados, the regime not is decides of a vez. Is actualiza

by tramos. Sea the sequence dividida in segmentos s = 1, , S. For each segmento is computed

a propuesta of regime candidata cand t,s and is mixture with the distribution previa low hysteresis, sorpresa and disagreement.

7.5. Hysteresis

The hysteresis prevents that a cambio local ruidoso provoque switching continuo:

persist = prev + h 1argmax(prev) ,

where h is a factor of persistencia.

7.6. Freeze pressure, disagreement and surprise

Three magnitudes regulan the cambio of regime:

• freeze pressure: how much tiempo lleva persistiendo a same regime. • disagreement: distancia between the distribution previa and the candidata. • surprise: magnitud of the cambio observacional between segmentos.

The score of evento can representarse as

$e_t = (E([z^{seg}_t , c^{slow}$

$_t , prev , z])) + 1$ disagreement + 2 surprise + 3 freeze.

The Final mixture between persistencia and candidato depende of if that score supera a umbral adaptable.

7.7. Contextual persistence

The persistencia not is interpreta as immobility. Is measures as the inverso of the switching effective. Therefore a persistencia excesiva can be tanto stability valiosa as freezing degenerada. The architecture distingue ambos casos introduciendo medidas of vitality contextual and entropy of regime.

8. Admissibility

8.1. Function

The admissibility is the filtro native that decides what part of the state can seguir living low the regime actual. Its function not is embellecer the state already formado, but legalize the trajectory before of the reading.

8.2. Operator form

Given the state transformado z_t and the slow context c^{slow}_t, the compuerta is computed as

$a_t = (W_2 (W_1 [z_t , c^{slow}$

$_t])),$

and is applied by producto of Hadamard:

$z^{adm}_t = a_t \; z_t .$

8.3. Architectural meaning

The admissibility cuts trajectories, regions or components cuya activation would be unproductive or illegitimate low the regime actual. A architecture without admissibility interna deja the problema of decidir what computar to the mixture indiscriminada of the state. CTNet, instead, legalizes internamente the calculation.

8.4. Admissibility and memory

The admissibility not destroys the memory; prevents that the memory is convierta in arrastre ciego. Only the part admisible of the substrate persiste toward the siguiente transition, and therefore the long memory not equivale to retenerlo all, but to retener it that can seguir actuando legalmente on the regime.

9. charts, selector, and route ecology

9.1. Local charts

From the state legalizado z^{adm}_t, the system computes K Local charts

(k)

$c_t = P_k (z^{adm}_t , c^{slow}$

$_t , m_t), k = 1, , K.$

Each chart is a reading projective distinta of the same background. No chart singular agota the whole.

9.2. Selector

The selector produces logits on charts from state medio, slow context, regime and memory:

$_t = S_{base} (z_t , c_t , _t) + S_{mem} (m_t) + S_{struct} (m^{loc}$

$_t$, TO) + S_{prior} (task) + S_{reg} ($_t$). slow

Then is applied a temperature effective $_t$ and is obtained

$_t = softmax(_t / _t).$

9.3. Temperature and ecological control

The temperature not is a constante fixes. Is ajusta in the tiempo and is combina with several correctores ecológicos:

• bias by chart infrautilizada, • penalty of charts dominantes, • recovery of charts funcionales deprimidas, • ajuste by priors of tarea when existan, • bias by structure memorial local/global.

The idea not is forzar uniformity, but impedir that the ecology of charts colapse prematuramente in a single branch soberana.

9.4. Structural weight of memory in the selector

The memory influye to the selector of two maneras. First by a bias directo of the Abstract global, t t + Wm m t ,

and second by a bias structural derived of three observables memoriales: variance local, desalineación local-global and weight topological fuera of diagonal. If denotamos

smem t), (mt , mt), OffDiag(TO)],

= [Var(mloc loc

t

then

t t + Wms st . mem

Not is seleccionan charts only by it that pide the tarea, but through the topology effective of the state memorized.

10. Readout and projective output

10.1. Role heads

Each chart is computed with a cabezal of role específico. The architecture can instanciar roles tales as local, shift, smooth, phase or a mixture general. Each head applies a pretransformación local to the state and then it combina with contexto and memory.

10.2. Three internal outputs

CTNet not produces a single projection candidata, but three familias:

• output blanda: combination convexa of charts, • output dura: projection of the chart dominant, • output base: projection general of the state without selection strict.

Formalmente,

(k) (k)

ytsof t = t ct ,

k

k = arg max t ,

(k) (k)

ythard = ct ,

k

ytbase = Pbase (ztadm , cslow

t , mt).

10.3. Final mixture

The output final not is obtained by a average trivial, but through a mixture dynamics dependiente of nitidez of charts, Contextual persistence and claridad of regime:

yt = h ythard + s ytsof t + b ytbase , h + s + b = 1.

The coeficientes is ajustan from the dominancia of the chart principal, of the stability contextual and of the state ecological of the charts.

10.4. Meaning of the projective output

The projective output prevents the error of sovereignty. The architecture not is ve obligada to fingir that a chart local coincide with the whole of the state. Eso libera computation, because the system not paga the

cost of compactar all in a single boca of output.

11. Coherence Tensor: definition

general

11.1. Architectural function

The Coherence Tensor not is a term of regularization decorativo. Is the operador that converts structure preservada into dynamic mass. Its work consiste in three operaciones simultáneas:

1. measure coherence,

2. convertirla in value structural,

3. do that that value altere realmente the transition, the learning or ambos.

The analytical part and the real part of the value coinciden because ambas are gobernadas by the same object tensorial.

11.2. Base coherence by cardinal halves

The coherence base of the state z = [u, p] defines by bidirectional consistency between the two

cardinal halves:

u = Flat (p), p = Flat

(u),

Ebase (z) = u u22 + p p22 .

This definition not weights simplemente two halves simétricas. Measures how much consigue each mitad sustain algebraicamente to the other dentro of the dynamics reversible. That weighting not is trivial: a mitad pesa by its capacidad of predecir and of be reconstruida by the other, not by its amplitud bruta.

11.3. Diagonal metric + low rank

On the state complete defines a metric anisotropic of coherence. Sea x RBŒN Œd and sea

xm = x mean(x). Is computed a variance by dimension,

v = mean(x2m) Rd ,

to part diagonal positiva,

Mdiag = softplus(m) + ,

and a low-rank correction given by a matriz L RdŒr . The structural information defines as

Idiag (x) = d

vi Mdiag,i ,

i=1

P = xm L, Ilow (x) = r

Var(Pj),

j=1

Idiag (x) + Ilow (x)

I(x) = .

d

11.4. From information to speed

The structural information not is deja as score analytical inerte. Is clampa for stability and is converts in speed effective:

Iclamped = clip(I(x), Imin , Imax),

speed(x) = exp(Iclamped).

Then the coherence whole defines as

Ecoh (x) = speed(x) Ebase (x).

The efficiency viene of that the tensor not usa a metric densa complete. The combination diagonal + low rank captura structure local and modes globales with cost mucho menor that a metric plena d Œ d.

11.5. Coincidence between analytical value and real value

If the value of a fraction is midiera by a score but the dynamics real siguiera other criterio, would divorcio between analysis and ejecución. CTNet prevents eso haciendo that the same quantity I(x) is transforme in speed effective. It that the system reconoce as more coherente not only vale more in the analysis; reorganizes realmente the system with more force.

12. Composite coherence and terms

structural

12.1. Beyond preservation

In the architecture complete, the coherence is not reduced to Ebase . Is composes with other terms:

• preservation of the substrate, • consistency between state and reading memorial, • tension statistical, • entropy of charts, • diversity between charts, • balance of load, • cost of routing, • Contextual persistence, • vitality contextual, • entropy of regime, • health of admissibility.

12.2. General form

A form genérica of the Composite coherence is

Ht = speed(zt)(p Epreserve +m Ememory +t Etension +c Ecards +d Ediversity +l Eload +r Eroute +cp Ectx_persist +cl Ectx_live

12.3. Interpretation of terms

• Epreserve : how much is rompe the consistency reversible of the substrate. • Ememory : distancia between state actual and reading memorial reintegrada. • Etension : desalineación between variance observada and perfil estadístico equilibrado. • Ecards : desviación of the entropy of charts respecto of the point of work deseado. • Ediversity : redundancia excesiva between charts. • Eload : desequilibrio of uso between charts. • Eroute : cost or improductividad of the routing.

• Ectx_persist : error of Contextual persistence respecto of the regime sano.

• Ectx_live : penalty by colapso contextual or switching patológico.

• Ectx_entropy : desalineación of the entropy of regime.

• Eadm : desalineación of the gate of admissibility respecto of the regime saludable.

12.4. Non-homogenization

Coherence not means forzar uniformity. Means reponderar the system for that the plurality not colapse nor is vuelva noise. The tensor not homogeneiza charts, memorias or branches; regula what diferencias can sostenerse estructuralmente.

13. Nontrivial weighting of u/p

13.1. It is not an average of halves

The weighting of u/p does not consist in asignar weights fijos to two halves of the vector. The system first establece a relation reversible between ellas and only after measures coherence. The weight of each mitad depende of how much structure válida consigue sustain the other.

13.2. Geometric interpretation

u and p are two charts cardinales of the same state. Its weight relativo viene given by:

1. consistency of reconstruction mutua,

2. structure global that generate jointly,

3. compatibility of that structure with the regime of branches activo.

13.3. Conclusion

The Nontrivial weighting of u/p prevents two reducciones poor:

• reducir the coherence to amplitud energética; • reducir the consistency to mere similitud point to point.

It that the tensor measures is compatibility structural reversible, not magnitud bruta.

14. Branch-wise coherence and object of

order

14.1. Order as an internal variable

The order not is treats as residuo estadístico nor as encoding posicional tardía. Is modela as object interno. For ello the architecture builds states by branch and segmentos of order.

14.2. Local masks

Sea oloc t a order object segmental. From it defines a mask local for the branch B,

mB , and a complementaria for the branch TO, mA = 1 mB . Then is construyen states by

branch:

ztA = mA zt , ztB = mB zt .

14.3. Branch-specific metrics

Each branch dispone of its own Diagonal metric and its own corrector low-rank. Therefore,

IA = I(ztA ; MA), IB = I(ztB ; MB),

where MA and MB not coinciden necesariamente.

14.4. Branch mass

The branches not is weight by a 0.5/0.5 fijo. The mass of each branch depende of the occupation real of the mask on the state:

pA = mean(mA), pB = mean(mB).

The information mezclada is

```
Imix = pA IA + pB IB .
```

14.5. Global stitching

In arquitecturas with stitching local-global, the mass local of branch is corrige through a operador of stitching that reequilibra segmentos between yes. The consecuencia is that the branch not pesa only by occupation local, but through occupation cosida globalmente. This makes that the order object not sea simplemente local nor puramente global, but composicionalmente estratificado.

14.6. Branch speed

The speed of Branch-wise coherence defines as

```
speedbranch = exp(Imix,clamped ).
```

Thus, each fraction of the value is guarda as producto of a Coherence Tensor idéntico in law, but aplicado to a soporte of branch distinto. The law tensorial is common; the diferencia procede of the soporte on the that acts.

15. Complete master equation of

CTNet

15.1. Compact form

A Compact form of the equation master of CTNet is

```
zt+1 = (TO(rev (zt , ut ), G(zt , mt , t , ut )), M (zt , mt ), Ht ),
```

acompañada by

(k) (k) (k)

```
t = S(zt+1 , mt+1 , t+1 ), ct = Pk (zt+1 , mt+1 , t+1 ), yt = t ct .
```

k

15.2. Expanded form

A form more explicit and cercana to the implementation is the siguiente:

```
zt = rev (zt ),
(gt , at ) = TO(zt , cslow
t ), ztadm = at zt ,
```

(mloc t , mt read

```
, mt ) = M (zt ),
```

(cslow

```
t , t ) = G(pool(zt ), mt , etask
```

t),

dmem

```
t = Wm [mread
```

t , mt], dctx

```
t = Wc [cslow
```

t , t , mt], dadm

```
t = Wa (ztadm zt ), dcoh
t = Wh (Ht ),
zt+1 = RMSNorm(zt + (m )dmem
```

t + (c)dctx t + (to)dt adm + (h)dcoh t),

```
t = Sbase (zt+1 , ct , t ) + Smem (mt ) + Sstruct (mloc
t , TO), t = softmax(t /t ),
```

slow

```
yt = h ythard + s ytsof t + b ytbase .
```

15.3. Comment

It decisivo of this equation not is that sea long. It decisivo is that deja ver that the transition interna, the legalization of the state, the memory, the coherence, the selection and the projection forman a single computational economy.

16. Contextual value and tensor of

coherence

16.1. From the perceived to fractions with contextual mass

CTNet does not treat it perceived as a block uniform. It divides in fractions internal of the state. Each fraction receives a weight contextual determinado by the Coherence Tensor. That weight not is a mero scale; porta suficientes dimensiones as for afectar simultaneously the part perceptiva of the structure and the part contextual of the realidad operativa.

16.2. Observation dimensions

Sea a familia of Observation dimensions = {1 , , m }. The architecture induce on each

fraction fi a weight contextual vectorial

$w_i = W(, f_i , H_t)$.

Not all observation pesa igual on all fraction. The dimensiones observacionales is convert in contexto when afectan algebraicamente of form distinta to each fraction.

16.3. Double algebraic effect

Each weight contextual has a effect double:

1. on the dimensiones perceptivas of the structure,

2. on the dimensiones contextuales that organizan the realidad operativa of the system.

If denotamos by Pi the effect on percepción and by Ci the effect on contexto, then the contextual value of a fraction can expresarse as

$V_i = V(P_i(w_i , f_i), C_i(w_i , f_i))$.

The fraction vale by how reorganizes ambos planes at the same time.

16.4. Coincidence between analytical part and real part of the value

The analytical part of the value is the measurement tensorial of structure; the real part of the value is the dynamic mass effective that that structure adquiere. In CTNet ambas coinciden because the same magnitud that measures structure passes to reponderar the transition. The value not is Comment externo on the dynamics; is the dynamics ponderándose to yes same.

17. long-memory mechanism

17.1. How the problem changes

CTNet not resuelve the long memory preguntando how transportar each vez more historia by a single canal. Changes the problema. The cuestión passes to be how maintain a state sufficiently rich, reversible, distributed and coherente for that the past siga actuando causalmente on the presente without collapse in a archivo linear.

17.2. Absence of to single bottleneck

The systems recurrentes clásicos tienden to sufrir because all must pass by the same hidden: memory, decision, control, señal and output. CTNet prevents that bottleneck because factoriza the act of computing:

• the substrate porta the background persistent, • the memory it distribuye in atlas, • the regime decides the modo of transition, • the admissibility legalizes the part living, • the coherence converts structure in mass, • the output projects without exhaust the background.

17.3. Result

The long memory deja of be retención indiscriminada of contexto. Passes to be preservation structural suficiente of the recorrido dentro of a state that not is identifies with no of its local outputs.

18. Complexity and inference

18.1. Computational economy

CTNet persigue a economy específica: calcular a vez on a substrate compartido and proyectar many. The cost of the calculation grueso is concentra in the transition of the state; the charts is leen after as proyecciones local of a background already trabajado.

18.2. Main costs

If N is longitud espacial/temporal, d dimension of the state, K number of charts, R number of regimes and r range of the Coherence Tensor, the costs dominantes is distribuyen in:

• mixture reversible and kernels multiradius: OR(N dJ), • Topological memory local/global: OR(N d + K 2 q), • selector and readout multi-chart: OR(KN d), • coherence diagonal + low-rank: OR(N dr).

18.3. Tensor efficiency

A metric complete on the state would have cost cuadrático in d. The form diagonal more low rank reduce the cost to algo cercano to linear in d for the part diagonal and linear in dr for the part structural global. That compression is a of the razones by the that the coherence can enter dentro of the step without do inviable the architecture.

18.4. Inference versus standard autoregression

Architecturally, CTNet ofrece a ventaja potencial in inference when several decisiones or readings must reusar the same background. A system puramente autorregresivo returns to pagar by memory, routing and contextualización dentro of the same canal dominant. CTNet can amortizar that cost on the substrate compartido and then proyectar several local outputs. The ventaja effective in latency real dependerá of the implementation and of the kernels disponibles, but the economy of architecture is claramente amortizada.

19. Invertibility, preservation and

stability

19.1. Exact invertibility e working invertibility

Not all CTNet has why be globalmente invertible in each componente. It decisivo is that the substrate principal conserve a propiedad strong of recovery operator. In the architecture canonical, the reversibilidad exact is da block to block. Other components can be not

invertibles and, aun thus, not destroy the propiedad structural central if operate as drives on a

background reversible.

19.2. RMSNorm and sigmoid gains

The normalization RMS and the gains acotadas by sigmoide controlan the scale of the drives of

memory, contexto, admissibility and coherence. This prevents explosiones directas and converts the transition in a suma modulada of campos internal:

```
zt+1 = RMSNorm(zt + (j )dt ).
```

(j) j

19.3. Stability and plurality

The stability not is compra sacrificando plurality. The architecture persigue a stability with bifurcaciones controladas, not a closure uniform. Ésa is the function conjunta of hysteresis of regime, selector ecological and Coherence Tensor.

20. Taxonomy of degenerations

20.1. Axis closure

Can obtenerse a degeneration architectural cerrando one or several axes of the space CTNet:

• without Topological memory, • without Dynamic regime, • without coherence effective, • without plurality of charts, • without projective output, • without order object, • without stitching local-global.

20.2. Formal reading

A degeneration not equivale necesariamente to fracaso whole of tarea. Can mejorar a error local and, at the same time, destroy structure of regime. This is a propiedad fundamental of the space CTNet: ajuste local and riqueza of regime not are equivalentes.

20.3. Poor regimes by overscaling

The Axis closure can be compensado parcialmente through sobreescala, but that sobreescala not recompone without more the space of computation clausurado. Is compra ajuste local, not necesariamente regime.

21. Implementation invariants

21.1. Structural invariants

A implementation concreta can variar in detalles always that preserve the siguientes invariants:

1. existencia of a persistent state distinto of the output;

2. transition reversible of the substrate;

3. memory reentrant and not only consultiva;

4. Native admissibility previa to the reading;

5. plurality of Local charts;

6. selector on charts and not a single ruta soberana;

7. coherence as mediator dynamic and not as loss terminal;

8. projective output;

9. order as variable interna when the tarea it requiera;

10. possibility of stitching local-global without destrucción of detail local.

21.2. Admissible variants

Are admissible variaciones in:

• number of radios, • number of charts, • form of the mixture dura/blanda/base, • detail of the topology memorial, • form exact of the order object, • modo in that the Coherence Tensor is injects in the transition or in the optimización.

21.3. The non-negotiable part

Not are admissible variaciones that colapsen architecture in a single dominant representation, conviertan the memory in archivo external puro or reduzcan the coherence to term decorativo without effect dynamic real.

22. Pseudocode of the step

computational

22.1. Elementary step

```
Entrada: z_t, m_t, _t, u_t
```

1. z_t _rev(z_t, u_t)

2. c_slow seed_context(pool(z_t), m_t, u_t)

3. _t seed_regime(pool(z_t), m_t, c_slow)

4. a_t TO(z_t, c_slow)

5. z_t^adm a_t z_t

6. (m_t^loc, m_t^read, m_t^glob) M(z_t)

7. H_t coherence(z_t^adm, m_t^read, a_t, _t?, _t)

8. d_mem mem_drive(m_t^read, m_t^glob)

9. d_ctx ctx_drive(c_slow, _t, m_t^glob)

10. d_adm gate_drive(z_t^adm z_t)

11. d_coh coh_drive(H_t)

12. z_{t+1} RMSNorm(z_t + (_m)d_mem + (_c)d_ctx + (_a)d_adm + (_h)d_coh)

13. _t selector(z_{t+1}, c_slow, _t, m_t^glob, m_t^loc)

14. {c_t^(k)} readout_heads(z_{t+1}, c_slow, m_t^glob)

15. y_t project({c_t^(k)}, _t)

```
Output: z_{t+1}, y_t, m_{t+1}, _{t+1}
```

22.2. Branch-wise coherence

```
Entrada: z_t, o_tˆloc, stitched_mass
```

1. m_B branch_mask(o_tˆloc, stitched_mass)

2. m_A 1 m_B

3. z_A m_A z_t

4. z_B m_B z_t

5. I_A metric_A(z_A)

6. I_B metric_B(z_B)

7. p_A,p_B masses(m_A,m_B)

8. I_mix p_A I_A + p_B I_B

9. speed exp(clip(I_mix))

```
Output: speed, I_mix
```

23. Expanded glossary of operators

23.1. Main operators

• rev : transition reversible of the substrate. • Flat : dynamics latent reversible interna. • M : Distributed topological memory. • G: dynamics of regime. • TO: admissibility. • S: selector multi-chart. • Pk : projection of chart local. • R: operador of reading/projection final. • H: coherence or tensor of value structural. • OR: order object. • Stitch: stitching local-global.

23.2. Canonical structural observables

• error of preservation, • error memorial, • tension statistical, • entropy of charts, • diversity of charts, • balance of load, • persistencia of regime, • vitality contextual, • entropy of regime, • coherence of branches, • discrepancia local-global of order.

24. Compact equations of

reference

For facilitar reading and citación interna, is reúnen here the compact equations mínimas of CTNet:

```
zt = rev (zt , ut )
at = TO(zt , t ), ztadm = at zt
mt+1 = M (zt , mt )
t+1 = G(zt , mt+1 , t , ut )
```

adm

```
Ht = H(ztadm , mt+1 , t+1 , at , t )
zt+1 = (ztadm ; mt+1 , t+1 , Ht )
t = softmax(S(zt+1 , mt+1 , t+1 )/t )
```

(k)

```
ct = Pk (zt+1 , mt+1 , t+1 )
```

(k) (k)

```
yt = K t ct
k=1
Ebase (zt ) = ut Flat (pt )2 + pt Flat
```

(ut)2 Idiag (zt) + Ilow (zt)

```
I(zt ) =
```

d

```
speed(zt ) = exp( clip(I(zt )))
```

```
Ht = speed(zt ) ( j Ej )
```

j

25. Final architectural discussion

CTNet not It must be read as accumulation of trucos modulares. It must be read as a reorganization of the act of computing. Its Reversible substrate changes the relation between step and loss; its Topological memory changes the relation between past and presente; its regime changes the relation between state and control; its admissibility changes the relation between calculation and legalidad interna; its selector changes the relation between state and reading; its Coherence Tensor changes the relation between value analytical and value real; and its projective output changes the relation between the whole and it visible.

The architecture only is understands when is ve how all those parts cooperan. If is quita the reversibilidad, the past pierde soporte structural. If is quita the Topological memory, the atlas is collapses in archivo or in olvido. If is quita the regime, the system pierde control fino of the modo of computar. If is quita the admissibility, the plurality is returns noise or rigidez. If is quita the coherence, the value remains separado of the dynamics. If is quita the projective output, the system returns to pagar the cost of fingir that a single chart agota the background. CTNet aparece, therefore, as a architecture of not colapso: not colapso of the state in the output, not colapso of the memory in archivo, not colapso of the routing in a single vía, not colapso of the order in encoding posicional, not colapso of the value in score externo.

26. Conclusion

CTNet architecture remains formulada here as a grammar operator complete. The persistent state evoluciona on a Reversible substrate and multiscale. The memory is distribuye topologically in a atlas of fractions that can aumentar its structure without aumentar of size. the regime regula the modo of transition. The admissibility decides what part of the state can seguir living. The Local charts leen the background without agotarlo. The selector organiza the ecology of those charts. The Coherence Tensor measures structure, the converts in value and da to that value mass real dentro of the dynamics. The order object converts the composition in propiedad interna of the calculation. The output is obtained by projection and not by recompactación whole of the state.

This is the point architectural decisivo: CTNet not describes only a form distinta of resolver tareas. Describes a form distinta of entender what means computar. Not part of a representation episodic to the that then is añaden memory, routing or control. Part of a space of computation in the that memory, regime, admissibility, coherence, charts and order are constitutivos of the Elementary step. The result is a architecture more cercana to a física of the computation that to a simple modelo of output.

Appendix TO. Detailed development of the

Coherence Tensor

TO.1. Diagonal metric

The part diagonal of the Coherence Tensor allows ponderar desigualmente the dimensiones of the state. If xm is the state centrado and vi the variance by dimension, the contribución diagonal

```
Idiag (x) = vii
```

i

expresa how much value structural porta each dimension low a weight positivo i .

TO.2. Low rank

The part of low rank capta modes globales of organization. If L RdŒr , then

```
P = xm L
```

projects the state on a base of modes relevantes, and

```
Ilow (x) = Var(Pj )
```

j

measures how much of the state is organizado in that subbase. The meaning of this operation is that many regularidades of the state not is manifiestan by dimension aislada but through combinaciones globales of dimensiones.

TO.3. Value fractions

Each fraction of the value can representarse as the result of aplicar the same law tensorial to soportes distintos of the state. If fi (z) is a fraction of the state, the contribución of value is

```
Vi = H(fi (z)).
```

All the fractions comparten law tensorial; it that changes is the soporte on the that that law acts.

TO.4. Efficiency

The Tensor efficiency deriva of three facts simultáneos:

1. not usa a metric complete but diagonal + low rank;

2. operates on fractions already topologically organizadas by the memory;

3. its output not remains as score analytical, but that reutiliza the same quantity for modular

transition and learning.

Appendix B. Detailed development of

the Topological memory

B.1. Partition of the state

Sea N the longitud of the state tokenizado. Defines a partition of tamaños s1 , , sK with

K

if = N .

i=1

Then

z = [z (1) , z (2) , , z (K)].

B.2. Chart local

Each chart local is obtained by a codificador regional more a base local:

m(i) = Ei (z (i)) + mean(B(z (i))).

B.3. Rotation

m(i) = Qi m(i) , Qi Qi I.

B.4. Feedback topological

mf b,(i) = Aij m(j) .

j

B.5. Mixture local-global

m(i) = (1)m(i) + mf b,(i) ,

(i)

mglob = (1)m(i) + mglob .

B.6. Reconstruction by atlas

The recuperabilidad simultánea is expresa as

1 K (i)

xt = Qi mt .

K i=1

The Strong thesis not is that no chart coincida with the whole, but that the whole can comparecer by composition coordinada of charts partial.

Appendix C. Pseudocode of

entrenamiento and audit

C.1. Entrenamiento

For each batch:

1. avanzar state by transition CTNet

2. proyectar charts and output

3. calcular loss of tarea

4. calcular terms of coherence

5. sumar loss whole

6. retropropagar

7. actualizar parameters

C.2. Audit structural

A audit minimal of CTNet must incluir:

• error of preservation reversible, • consistency memory-state, • entropy and load of charts, • persistencia and vitality contextual, • information of coherence, • speed of coherence, • metrics of the order object when exista.

Appendix D. Table of

correspondencias operatorias

Símbolo Meaning technical zt persistent state ut , pt cardinal halves of the state rev transition reversible of the substrate Flat dynamics latent reversible mt memory global (i) mt chart memorial local TO topology of coupling between fractions t distribution of regime at compuerta of admissibility t distribution on charts (k) ct chart local k Ht coherence ot order object Stitch stitching local-global yt projective output

Appendix E. Principios not

negociables of design

1. The state must be persistent and distinto of the output.

2. The substrate must preserve structural information suficiente between steps.

3. The memory must reentrar in the transition presente.

4. The admissibility must actuar before of the reading.

5. Must existir plurality interna of charts.

6. The selector cannot be reduced to a single vía fixes.

7. The coherence must have effect dynamic real.

8. The order must poder be a variable interna of the calculation when the dominio it exija.

9. The output must be projective and not soberana.

10. The architecture must permitir recuperabilidad by atlas or by trajectory without autorizar

exhaustion by a single chart.

Appendix F. Consequences directas

for the design of systems

1. The systems with long memory must diseñarse as economías of preservation, not only

of almacenamiento.

2. The coherence must convertirse into dynamic mass and not quedarse as criterio of evaluation.

3. The plurality of readings not is a cost extra if the substrate is amortizado.

4. The control interno must separarse of the output for avoid colapso funcional.

5. The efficiency real depende of factorizar bien the act of computing and not only of optimizar

kernels on a base architectural pobre.

27. Derivation detallada of the

Topological memory

27.1. Motivo architectural

A memory that consistiese in a single vector global sufriría a tension inmediata. If the vector is makes small, not can alojar suficiente historia operativa. If is makes grande, is converts in a archivo caro that requires procedimientos posteriores of reading for volver to be useful. CTNet prevents that bifurcación pobre distribuyendo the memory in a topology of fractions local that tocan the whole only as parcial. The idea básica is that the memory not must guardar a copia exhaustiva of the state, but a familia of charts of high reutilización.

The derivation complete of this memory has five levels: segmentación of the state, Local encoding, rotation of charts, feedback topological e Injection of the whole. The composition of those levels is it that converts a memory parcial in a memory of high densidad structural.

27.2. Segmentación of the state

Sea zt RN Œd . Defines a partition of the axis N in K fractions. If if denota the size of the fraction i, then

(1) (K)

```
N = K if , zt = [zt , , zt ].
i=1
```

The architecture not requires that all the if sean iguales. It that requires is that the fractions cubran the state and that the asignación token-fraction can volver to reconstruirse for reinyectar memory by token. This is a detail important: the topology memorial not vive ‘‘by encima’’ of the state, but literally in its partition.

27.3. Encoding of base and encoding regional

TO each token is le applies first a encoding basal,

```
bt,n = B(zt,n ),
```

and to each fraction a encoding regional,

(i) (i)

```
rt = Ei (zt ).
```

The chart local preliminar of the fraction combina ambas:

```
mt = mean(bt ) + mean(rt ).
```

(i) (i) (i)

This not is redundante. The encoding basal preserves a reading of token that será useful more adelante for reinjection local; the encoding regional capta structure of the fraction as fraction. The average of ambas prevents that the memory local sea puramente microscópica or puramente macroscópica.

27.4. Rotation ortogonal and plurality of charts

If all the fractions is dejasen in the same base, tenderían to superponerse algebraicamente. For impedirlo is applied to each fraction a rotation específica:

(i) (i)

```
mt = Qi mt , Qi Qi I.
```

The meaning technical of this operation not is decorativo. First, makes that distintas fractions puedan representar the whole low orientaciones distintas. Second, reduce aliasing between Local charts. Third, mejora the reconstruction by atlas, because the inversión of the chart local not obliga to all the fractions to vivir in the same Geometry.

27.5. Topology of coupling

The Local charts not is dejan aisladas. Is definen interacciones between ellas through a topology learned:

```
TO = softmax(), TO RKŒK .
```

The feedback topological of the fraction i is

(i) (j)

```
mf b = K Aij mt .
j=1
```

This topology has a interpretation inmediata: expresa what fractions is consideran mutua- mente relevantes for sustain the whole. The caso diagonal puro would be a memory without interaction. The caso completamente uniform would be a memory indiferenciada. CTNet aprende a topology intermedia where the dependencia not is nor nula nor trivialmente whole.

27.6. Injection of the whole and mixture fraccional

Moreover of the atlas local, the architecture computes a Abstract global of the state:

mglob

```
t = G(zt ).
```

The mixture of information local, topological and global is makes in two fases:

(i) (i) (i)

```
mt = (1 )mt + mf b ,
```

(i) (i)

```
mt = (1 )mt + mglob
```

t .

This double mixture prevents two extremos. If only is usara mglob t , the memory recaería again in a chart soberana single. If only is usaran Local charts, the system perdería continuidad of the whole. The mixture is precisamente it that allows that the all siga actuando without destroy the plurality.

27.7. Reinjection token-local

Each token receives memory by a mixture ternaria:

(i(n))

```
t,n = T (bt,n , mt , mt ).
```

This point is crucial for entender why the memory reentra in the transition presente. The token not consulta a archivo to posteriori; the token porta already a update that depende of its base local, of the chart of its fraction and of the whole global. The presente is reorganizes by the past without pass by a retrieval separado of the step.

27.8. Recuperabilidad simultánea and by retardos

The architecture admite two forms of recuperabilidad.

Primera: recuperabilidad simultánea coordinada,

(1) (K)

```
xt = R(mt , , mt ; TO, Q, t ).
```

Segunda: recuperabilidad temporal by retardos,

( ) (1) ( ) (K) xt Rdelay (D11 mt , , DKK mt).

The architectural thesis that is sigue is very strong: no chart singular coincide with the whole, but the whole can comparecer funcionalmente by composition of charts or by trajectory temporal. This propiedad is the reason deep by the that the memory can crecer in structure without crecer in size.

28. Derivation detallada of the regime

28.1. What problema resuelve the regime

If the state reversible and the Topological memory already preservan mucha structure, could parecer that the regime is accesorio. Not it is. Without regime, the system would have that tratar all cambio as homogéneo. the regime introduces a variable of control interno that decides how must computarse in each tramo of the trajectory. Its object not is nombrar a tarea, but seleccionar a modo of transition.

28.2. Seed contextual

The derivation arranca by a seed contextual lenta obtenida from state medio, memory and contexto externo:

cslow

```
t = Cslow (zt , mt , etask
```

t).

The slow context already is a reducción very distinta of a simple embedding of tarea. Resume the modo actual of the system and sirve as base of legalization for the admissibility.

28.3. Distribution inicial of regime

On that base is obtained a Regime seed

seed

t = softmax(W[zt , mt , cslow

t]).

The distribution of regime can representarse as a simplex on R modes. Not is requires that the architecture elija one of form dura in all the steps. It important is that the distribution

controle already other modules: selector, drives of transition, and eventualmente the order object.

28.4. Regime segmental

In dominios where the state has structure segmental, the update of the regime is makes by tramos. Sea zt,s the state average of the segmento s. Then builds a propuesta candidata

t,s = softmax(T ([zt,s , ct , t,s1 , zt,s])).

cand slow

The propuesta not is adopta without more. Must pass by a mechanism of persistencia, sorpresa and disagreement.

28.5. Hysteresis and persistencia

If denotamos by t,s1 the logits previos, the persistencia is refuerza through a vector one-hot on the branch dominant:

persist = t,s1 + h 1arg max t,s1 .

The factor h can depender of the pressure of freezing. This makes that the persistencia sea a propiedad activa, not a inercia pasiva.

28.6. Freeze pressure

Sea aget the edad of the regime dominant, that is, cuántos steps ha persistido without cambio. The pressure of freezing defines as a function creciente of that edad,

f reezet = f (aget), f > 0, 0 f 1.

The pressure of freezing not busca destroy persistencia. Busca distinguir living persistence of persistencia muerta. When the regime lleva demasiado tiempo repitiéndose and, moreover, the entropy interna is low, the system gana incentivos for explorar other transition.

28.7. Disagreement and sorpresa

The disagreement is computed as a distancia simétrica between the distribution previa and the candidata, by ejemplo a mean of divergencias KL. The sorpresa is computed from the diferencia between promedios segmentales sucesivos. Ambas magnitudes is suman to the score of evento:

et,s = (E([zt,s , cslow

t , t,s1 , zt,s])) + d disagreementt,s + s surpriset,s + f f reezet .

28.8. Umbral and Final mixture

The architecture not conmutará of regime if the score not supera a umbral. This umbral also is adaptable:

t,s = 0 + 1 (1 H(t,s1)) 2 f reezet 3 disagreementt,s 4 surpriset,s .

From there sale a coeficiente of mixture

et,s t,s

t,s = clip (, 0, 1),

with the that is combinan logits persistentes and logits candidatos.

28.9. Outputs of the regime

The dynamics devuelve more that a distribution final. Devuelve also observables structural: tasa of switching, persistencia effective, variance of regime, entropy and magnitudes auxiliares of freeze, disagreement and sorpresa. These magnitudes not are decorativas. The Coherence Tensor the usa more adelante for estimar health contextual.

29. Geometry of the admissibility

29.1. Legalization and not simple sparsificación

The admissibility suele malinterpretarse as sparsificación of the state. In CTNet not. The com- gate decides what part of the state can seguir living in the regime actual without volver unproductive or illegitimate the transition. This quiere decir that the admissibility has status geometric, not only estadístico.

29.2. Tensor of gate

Given zt and the slow context, the compuerta produces a campo at [0, 1]N Œd . The multiplicación

```
ztadm = at zt
```

defines a region admisible of the state. That region not has why be small. It that importa is that esté alineada with the regime and with the Topological memory.

29.3. Diferencia between state bruto and state legalizado

The diferencia

adm

```
t = ztadm zt
```

```
not is tira. Is projects and is reinyecta as gate_drive. This means that the admissibility not
```

only cuts; informa to the transition siguiente of what part of the state fue legalizada and which not. The architecture aprende thus the diferencia between background bruto and background legalizado.

29.4. Health of admissibility

The coherence not mira only the value medio of the gate. Mira also its variance. A gate comple- tamente plane can indicar falta of discriminación. A gate excesivamente colapsado can indicar closure prematuro. The term of health of admissibility compara mean and variance of the gate with a zona of work structural.

29.5. Admissibility and memory long

Without admissibility, a long memory corre the riesgo of convertirse in accumulation caótica of residuos. With admissibility, the persistencia deja of be equivalente to retención indiscriminada. The system preserves past only in the region of the state that sigue siendo legal for the regime actual.

30. Ecology of the selector and antipsoidía

of charts

30.1. Problema

A architecture multi-chart collapses fácilmente if the selector converge demasiado pronto to a single chart dominant. CTNet resuelve this not forzando uniformity, but construyendo a ecology of charts where the dominancia is allows only when is respaldada by regime, memory and coherence.

30.2. Components of the logit

The logit whole of the chart k can escribirse as

(k) (k) (k) (k) (k)

```
t = base + task + regime + mem + memstruct + eco .
```

(k) (k)

Each term performs a function:

• base: reading of the state medio, contexto and regime; • task: bias opcional of tarea; • regime: correspondencia directa between regime and charts; • mem: bias of the Abstract memorial global; • mem-struct: bias derived of observables topológicos of memory; • eco: correcciones ecológicas by infrautilización or dominancia.

30.3. Temperature effective

The temperature effective viene given by a temperature basal more a multiplicador of schedule. Its function is permitir that the selector arranque with more mixture and is vaya decantando without perder elasticidad.

30.4. Uso medio, uso in ventana and necesidad vital

The architecture maintains to the less two estadísticas of uso of charts: a EMA lenta and a mean in ventana. From ellas computes necesidad of charts infrautilizadas and penalty of charts sobredominantes. Not is busca igualar all the charts; is busca impedir that the architecture pierda capacidad of routing by closure ecological prematuro.

30.5. Not trivialidad of the routing

The routing in CTNet not is a gate all/nada, nor a attention difusa without compromiso. Is a distribution regulada by ecology, memory and regime. Therefore the entropy of charts and the balance of load aparecen as terms of coherence: are indicadores directos of health of the space of rutas.

31. Descomposición of the readout and

damping of the substrate

31.1. Reason of three outputs

The readout maintains Three internal outputs because the system not must elegir demasiado pronto between rigidez and mixture. The output dura preserves the chart dominant. The blanda allows amortizar several charts. The base maintains a projection general of the state. The Final mixture decides how much of each a it is advisable in function of the contexto effective.

31.2. Dominancia contextual

The dominancia not is only the pico of the selector. Is composes of nitidez of charts, Contextual persistence and claridad of regime. Eso means that a chart not domina only because the selector tenga mucho pico, but because the system is in conditions of dejar that that chart represente with poca loss the work of the momento.

31.3. Damping of substrate

The diferencia with arquitecturas monolíticas is clara. A architecture monolithic returns to pagar computation when necesita reorganize memory, contexto, routing and output dentro of the same canal. CTNet concentra work in the substrate and reutiliza that work in several charts. The damping is produces because the cost of the background is paga a vez and the readout explota that background without destruirlo.

31.4. Condition of éxito

The damping only is real if the charts not are redundantes and if the selector can mover mass between ellas without collapse. Therefore diversity, balance and route loss reappear as terms of coherence.

32. Derivation fina of the tensor of

coherence and of the value

32.1. Why the efficiency not is trivial

The Coherence Tensor logra efficiency because not separa analysis and dynamics. Measures structural information with a object comprimido and usa that same magnitud for modificar the comportamiento real of the system. If the analysis of the value estuviese separado of the dynamics, would that pagar two times: a for measure and other for actuar. CTNet paga a single vez.

32.2. Fractions of the value

Each fraction of the value is guarda as producto of a Coherence Tensor idéntico in law to the that acts on the state global. The law tensorial is common; the fractions difieren in the soporte of the state on the that is applied. Sea fi (z) a fraction, then

$V_i = H(f_i(z)), \; V = i \; V_i .$

i

The weights i not are arbitrarios; vienen given by the mass effective of each fraction dentro of the regime actual.

32.3. Conversión of value in mass

If denotamos the analytical part of the value by Ii and the mass real by i , then the coincidence between ambas is escribe as

$i = \exp(\mathrm{clip}(I_i)).$

Not there is a function externa that then decida what do with Ii . The own form of i makes that the value is vuelva force interna of the system.

32.4. Coherence of branches and contextual value

In dominios of branches, the contextual value of a fraction depende not only of its information aislada but of its mass real dentro of the state. If a branch ocupa poca part of the state, its

information pesa less. If ocupa mucha, its information pesa more. Therefore the contextual value combina calidad structural and occupation real:

$V_A = p_A I_A , \; V_B = p_B I_B , \; V_{mix} = V_A + V_B .$

32.5. Consecuencia

The Tensor efficiency proviene of that the calculation of value already is factorado by fractions of the state and of that its result entra directamente in the transition or in the reorganization of the learning. Not there is a capa semantic external that traduzca then the value to dynamics.

33. Order object and stitching

local-global

33.1. Necesidad of a order object

If the dominio is composicionalmente not conmutativo, tratar the order as encoding posicional is insuficiente. CTNet introduces a object interno of order because the trajectory of the calculation changes if changes the order of composition.

33.2. Order local by segmento

Sea the sequence dividida in segmentos. Each segmento receives a Branch mass B,

```
pB,s = Os (zt,s , mt , t ),
```

of the which sale a mask local of order. The order local not is a score decorativo but a mass that reorganizes the state by branches.

33.3. Global stitching

The stitching takes the masas local and builds a mass global corregida,

```
pB = Stitch(pB,1 , , pB,S ).
```

With ello the order deja of be suma of decisiones local and is returns structure costurada. The system can thus preserve detail segmental without perder coherence global.

33.4. Uso in readout and coherence

The order object not is usa only in a head auxiliar. Alimenta the readout of branches, the Branch-wise coherence and the audit structural of the system. Therefore the order is converts in propiedad real of the calculation and not in variable statistical tardía.

34. Geometry of the gradient and

reorganization of the learning

34.1. Two lugares posibles for the coherence

The coherence can enter of two forms:

1. as term dentro of the loss whole;

2. as modulator directo of drives internal or incluso of scale effective of update.

CTNet architecture admite ambas. The reason is that the value structural can and must influir tanto in the transition of the state as in the speed with that the system reorganizes its parameters.

34.2. Scaling of gradientes by coherence

If the coherence devuelve a factor of speed,

```
speed = exp(Iclamped ),
```

is posible usarlo also for reponderar the learning:

L clip(speed) L.

This not means that a region coherente aprenda always more rápido without control. Means that the reorganization paramétrica can be acelerada allí where the structure of the state the makes more fiable.

34.3. Architectural meaning

The learning deja of be a correction blind guiada only by error final. Passes to be a reorganization guiada by structural health of the own computation.

35. Propositions architectural and

bosquejos

35.1. Proposition of not sovereignty of output

Proposition. If the output is obtained by projection multi-chart from a persistent state that not is identifies with no chart singular, then no output local agota by yes single the contenido computational of the step.

Bosquejo. The charts are computed from the same substrate and the output is combination or selection between ellas. As the substrate preserves more structure that the reading final and as the charts are multiple, the output visible not coincide with the whole of the state.

35.2. Proposition of crecimiento memorial without crecimiento of

size Proposition. Low Distributed topological memory, the value recoverable of the past can crecer although the dimension bruta of memory permanezca constante.

Bosquejo. The crecimiento not ocurre by number of slots but through densificación of the atlas of relaciones between fractions, Abstract global and trajectory. The recuperabilidad increases because a same dimension memorial participa in more reconstrucciones and more cierres useful.

35.3. Proposition of coincidence between value analytical and real

Proposition. If the dynamic mass of a fraction is function monótona of the same funcional that measures its structural information, then the analytical part and the real part of the value coinciden architecturally.

Bosquejo. The measurement I not is remains as score. Is transforms in speed or in weight of transition. Therefore the system not only sabe what vale more; acts already as if that valiera more.

35.4. Proposition of necesidad of the tensor comprimido

Proposition. A metric complete of the state not is necessary for capturar coherence relevante if a Diagonal metric more a low-rank correction already cubre dimensiones local and modes globales.

Bosquejo. The part diagonal measures anisotropy by coordenada. The part low-rank captura correlaciones dominantes in subespacios relevantes. All structure that not between ahí podrá modelarse aumentando range, without necesidad of pass to a metric densa complete from the outset.

36. Closure final

The space CTNet can resumirse of form extrema in the siguiente frase: the computation is the governed evolution of a background persistent cuya structure is preserva, is fractionates, is legalizes, is memoriza topologically, is reweights by coherence and is projects only after in local outputs. All the aparato technical desarrollado in this monograph not makes other cosa that desplegar that frase in operators, topologies, equations and observables.

The architecture importa because shifts the lugar where vive the work real of the system. In lugar of vivir in a representation episodic that must cargarlo all and then olvidarse, the work vive in a Persistent substrate. In lugar of vivir in a cache externa, the memory vive in the transition. In lugar of vivir in a penalty tardía, the coherence vive in the dynamic mass of the value. In lugar of vivir in a reading single, the output vive in a space multi-chart. In lugar of vivir in a simple posición, the order vive as object. Ése is the core technical of

CTNet and ésa is the reason by the that the architecture not is deja reducir to a list of bloques nor to

a version concreta.

Appendix G. Despiece operador by

operador of the reversible substrate

G.1. Router

The Invertible router is the operador more simple of the whole and, however, performs a function important. Its role not is aumentar capacidad by yes same, but impedir that the same grupos of coordenadas permanezcan always acoplados. A permutation fixes, invertible and conocida by the inversa allows redistribuir the information between cardinal halves without loss.

G.2. Partition

`The partition x = [x1 , x2 ] not It must be read as a detail of implementation. Is the condition`

for that the block can aplicar additive couplings exactos. The mitad x2 actualiza to x1 and the result y1 returns then on x2 . This induce a dependencia strong between halves without destroy the recovery exact.

G.3. Functions F and G

The functions F and G not are MLPs arbitrarias colocadas dentro of a esquema reversible. In CTNet are operators kernelizados multiradius, of modo that the coupling between halves already incorpora structure espacial or secuencial. The reversibilidad not is then a simple propiedad formal of the block: is reversibilidad on a campo estructurado by vecindades of several radios.

G.4. Gains

The gains and lat not are hiperparámetros accidentales. Its function is double: controlar the scale of the coupling and permitir that the block is mantenga in a zona in the that the recovery siga siendo estable. The architecture is diseñada for that the evolution principal sea suma modulada, not sobrescritura agresiva.

Appendix H. Anatomy complete of the

selector

H.1. Pooling of the state

The selector part of a state medio. This operation not means that be reduced the system to a mean flat. Means that necesita a statistical global barata from the that iniciar the calculation of logits. On that base then entran memory, structure memorial, regime and correcciones ecológicas.

H.2. Bias by tarea and bias by regime

The sesgos by tarea and by regime not cumplen the same role. The first codifica afinidades of superficie when the dominio it justifica. The second expresa a law mucho more strong: that ciertos regimes must favorecer ciertas charts by definition architectural. the regime not is a etiqueta auxiliar; is a source native of Geometry for the routing.

H.3. Structure memorial as bias of charts

The architecture not deja the memory in the readout. The usa also for sesgar the selector. The Abstract global adds a bias directo. The structure memorial adds a bias indirecto. Thus, two states with the same average token to token can recibir ecologías of charts distintas if its topology memorial is distinta.

H.4. Correction anti-dominancia

The anti-dominancia not persigue repartir the uso of charts by igual in all circunstancia. Persigue impedir cierres prematuros of the space of rutas. A chart can dominar if of verdad concentra value structural. It that the architecture bloquea is that a chart domine only by inercia of optimización or by a mala ecology local.

Appendix I. Anatomy complete of the

readout

I.1. Role semántico of each head

The familia of heads allows interpretar the readout as a colección of operators with sesgos geométricos diferentes. A head local enfatiza vecindad próxima. A head shift enfatiza transporte. A head smooth enfatiza stabilization. A head phase enfatiza alternancia or asimetría. Not is necessary fix this list of form dogmática; it necessary is that the space of charts permita several readings not colapsadas of the same substrate.

I.2. Base projector

The output base performs a function estratégica. Garantiza that the system not dependa always of a decision strong of the selector for produce a projection válida. Is a reserva of legibilidad of the state and a form of impedir that the architecture tenga that pass by a single chart dominant in all the trajectories.

I.3. Full mode

The modo full mixture hard, soft and base. This not is a concesión ecléctica. Is a manera of permitir that the system adapte the grado of compromiso of the output to the health of the regime and to the nitidez of the selector. In zonas of high claridad, the output dura can pesar more. In zonas of plurality real, the mixture suave or the output base can sustain mejor the fidelidad of the state.

Appendix J. Development extendido of the

order object

J.1. Order local

The order local comparece as Branch mass or as distribution on alternativas of composi- ción dentro of a segmento. Not is treats of recuperar a posición absoluta, but of establecer what reading composicional of that segmento must activarse.

J.2. Order global

The order global not sustituye to the order local. It cose. This means that a branch can be localmente dominant and, however, quedar reponderada by the consistency global of the trajectory. The stitching corrige the sovereignty local without destroy the information local.

J.3. Desacuerdos structural

The architecture measures several desacuerdos relevantes: between mass local and mass global, between mass of branches and distribution of regime, and between mass costurada and mass observada. These desacuerdos not are errores cualesquiera; are indicadores of health composicional of the system.

Appendix K. Derivation alternativa

of the equation master

A form useful of reorganize the equation master consiste in separate the step in three bloques: constitución of the background, legalization, and comparecencia.

First, constitución of the background:

```
(ztrev , mt , t ) = (zt , ut , mt1 , t1 ).
```

Second, legalization:

```
ztleg = TO(ztrev , t ) ztrev .
```

Third, comparecencia:

(k)

```
{ct }, t , yt = (ztleg , mt , t , Ht ).
```

This reorganization shows that the core of the system is the construction of the background. The compare- cencia viene after.

Appendix L. Consequences for

design of hardware and kernels

A architecture that computes a vez on a background and projects many plantea a problema of hardware distinto to the of a architecture that reitera reescrituras of representation. In CTNet has meaning optimizar:

1. kernels of multiradius mixture reversibles;

2. operaciones of partition and coupling by cardinal halves;

3. Orthogonal rotations ligeras for charts memoriales;

4. proyecciones low-rank for coherence;

5. stitching local-global of the order object.

This mapa is important because the cost of pared not viene only of the theory of complexity abstract. Depende also of what primitives can compilarse bien to the hardware. CTNet redistributes the cost toward primitives that can be very favorables if is optimizan as familia and not as parts sueltas.

Appendix M. Mapa of fallos

structural and síntomas

M.1. Colapso of charts

Symptom: entropy very low, diversity very low, balance of load desalineado. Causa arquitec- tónica probable: selector demasiado rigid or coherence without suficiente sensibilidad ecological.

M.2. Persistencia congelada

Symptom: switching almost nulo, persistencia enorme, entropy of regime insuficiente. Causa probable: hysteresis sobredominante or falta of anti-freeze.

M.3. Deriva contextual

Symptom: switching high without stabilization, sorpresa high sostenida, disagreement high. Causa probable: regime demasiado reactivo or admissibility incapaz of legalize trajectories useful.

M.4. Memory flat

Symptom: charts memoriales almost idénticas, topology cercana to uniform, reconstruction by atlas pobre. Causa probable: falta of diferenciación rotacional or falta of tension structural between fractions.

M.5. Coherence cosmética

Symptom: the value of coherence changes but not altera the transition nor the learning. Causa probable: the coherence ha quedado reduced to loss decorativa and ha perdido status architectural.

Appendix N. Table extensa of

equations and operators

Equation Interpretation

```
zt = rev (zt , ut ) transition reversible of the substrate
at = TO(zt , t ) legalization of the state
ztadm = at zt state admisible
mt = M (zt , mt1 ) memory reentrant
t = G(zt , mt , t1 , ut ) dynamics of regime
t = softmax(t /t ) distribution on charts
```

(k)

```
ct = Pk (zt , mt , t ) chart local
```

(k) (k)

```
yt = k t ct projective output
Ebase = u u2 + p p2 coherence cardinal base
```

| +|

```
I = diagd low structural information
speed = exp( clip(I)) dynamic mass of the value
```

```
Imix = pA IA + pB IB Branch-wise coherence
```

(i)

```
xt = K 1
```

i Qi mt reconstruction by atlas

```
t = base + reg + mem + eco logit selectorial compuesto
```

37. Recorrido microscópico of a

ciclo complete

37.1. Step cero: state available

Supongamos available a persistent state zt of size N Œd. It first that must be understood is that this state not is a ‘‘representation final’’ pendiente of interpretation, but the lugar where still vive the work not agotado of the system. Its form concreta importa: is organizado cardinalmente in halves, espacialmente in posiciones or tokens, and topologically in fractions memoriales posibles.

37.2. Step one: transformation reversible of the background

The primer movimiento not is leer the state, but transformarlo without destruirlo. The router it permuta, the block reversible part the state in two halves and the acopla aditivamente, and the branch latent makes that a mitad carry structure on the other before of the segunda mitad of the coupling. The result is zt . Is important insistir in this: up to here the system not ha intentado produce no output. Ha trabajado only on the background.

37.3. Step two: observation memorial of the state previo

Mientras the substrate is prepara for avanzar, the system computes memory on the state available. This is crucial because the memory that reentrará in the transition siguiente not is computed from a output local, but from the own persistent state. The state is fragmenta, each fraction builds its chart local, the charts is rotan, is acoplan topologically, is injects a Abstract global and finally builds a memory token-local that can volver to tocar the state in the siguiente step.

37.4. Step three: siembra of slow context and regime

With state medio and memory available is siembran slow context and distribution of regime. The slow context defines the tono of legalization of that tramo. The distribution of regime defines the tipo of computation preferible. Not is treats of two decoraciones encima of a state already fact: ambas variables preparan the conditions of the transition siguiente.

37.5. Step four: admissibility

Ahora yes is decides what region of the state can seguir living. The admissibility observa the state transformado and the slow context, and produces a gate. The state admisible not is a new hidden cualquiera; is the region legal of the substrate low the regime actual. The part of the state that remains fuera not desaparece without dejar huella: its diferencia respecto of the state bruto is converts after

in a drive específico.

37.6. Step five: construction of drives

CTNet not actualiza the state with a single force interna. Builds several drives, each one with

meaning own:

• the drive of memory, that expresa how the past reentra in the presente;

• the drive of contexto, that expresa how the regime and the slow context must deformar the

background;

• the drive of admissibility, that expresa the diferencia between background bruto and background legalizado;

• the drive of coherence, that expresa the mass structural effective of the value.

The update of the state siguiente not is, therefore, ‘‘a function’’. Is the suma modulada of several campos internal on the same substrate.

37.7. Step six: coherence as mass

If the coherence fuese a loss terminal, this step not existiría. In CTNet yes existe. The Coherence Tensor measures information and consistency of the state and, from ellas, produces mass

dynamics. This mass entra as drive or as modulator of reorganization. Is here where the

analytical part and the real part of the value dejan of ir separadas.

37.8. Step seven: new state

The new state is obtained sumando all the drives to the background reversible and renormalizando. The result not is a simple function of the entrada reciente; is a reorganization of the background that already integra past, legalidad, coherence and modo of computation.

37.9. Step eight: charts and projection

Only ahora is construyen charts, the selector decides distribution on ellas and the output comparece by projection. This cronología is the marca more deep of the architecture. The system not produces first a output and then intenta salvar memory or coherence. Builds first the campo and projects after.

38. Spaces of forms and semantic

geometric of the dimensiones

38.1. Dimension token, dimension cardinal and dimension memorial

CTNet operates simultaneously on several geometrías. The primera is the Geometry token or espacial, indexada by N . The segunda is the Geometry cardinal, indexada by the partition u/p. The tercera is the Geometry memorial, indexada by fractions and by dimension of memory. No of these three coincide with the other.

This separation allows that a same dimension algebraica not tenga that cargar all the papeles at the same time. A axis can have relevancia topological and not of output. Other can have relevancia of output and not of memory. Other can be central for coherence and almost invisible for the projection final. This especialización of spaces is a of the razones by the that CTNet reduce aliasing structural.

38.2. Geometry of observation and Geometry of action

The mayoría of arquitecturas mezclan observation and action on the same soporte. In CTNet there is a diferencia more fina. The dimensiones on the that is measures coherence not coinciden necesariamente with the dimensiones on the that is projects output. Of the same modo, the dimensiones on the that is establece topology memorial not coinciden with the dimensiones cardinales of the coupling reversible. This separation allows that a propiedad sea observada and, however, not sea inmediatamente collapsed in the canal of output.

38.3. Effect on the stability

Separate spaces of form reduce the pressure that a single variable ejerce on the whole. When a architecture obliga to that all comparezca in the same space, cualquier intento of estabilizar to part tiende to dañar other. CTNet disminuye that tension repartiendo functions by geometrías distintas, although coordinadas.

39. Development mathematical of the value

contextual

39.1. Value as funcional and not as etiqueta

The contextual value in CTNet not is a etiqueta that is asigne after of measure a state. Is a funcional that surge to the aplicar the Coherence Tensor on fractions of the state low a regime and a topology given. If fi (zt) is the fraction i and H the Coherence Tensor, then

`Vi = H(fi (zt ); t , mt , ot ).`

The dependencia in regime, memory and order expresa that the value not is absoluto; is structural- mente situado.

39.2. Weight contextual multidimensional

Each fraction receives a weight contextual vectorial

(1) (m)

`wi = [wi , , wi ],`

cuyas components can representar persistencia, compatibility, tension, direccionalidad, centralidad of branch, coherence of atlas, effect on selector and effect on order. The point strong is that the weight deja of be a coeficiente scale. Is converts in a object of several dimensiones observacionales.

39.3. Double action algebraica

This weight acts in two planes distintos:

`Pi = P (fi , wi ), Ci = C(fi , wi ).`

Pi modifica the comparecencia perceptiva of the fraction dentro of the structure. Ci modifica the comparecencia contextual of that fraction dentro of the regime and of the realidad operativa of the system. The contextual value emerges of the composition of ambos:

`Vi = V (Pi , Ci ).`

39.4. Coincidence between analysis and realidad of the value

The reason by the that the value not is remains in analysis is that the same magnitud that produces Vi is usa for reponderar drives or velocidades. This can expresarse in abstract as

$(i)\ (i)\ z_t\ (V_i)\ z_t$,

where is a function monótona of the value tensorial. The fraction not only vale more in the role; acts more dentro of the system.

40. Interaction between coherence and

memory

40.1. Problema general

Memory and coherence could parecer two objetos independientes: the primera conservaría structure, the segunda the evaluaría. In CTNet not is thus. The coherence evalúa a memory already topologizada and, to the hacerlo, can afectar to the form in that that memory returns to enter in the transition. Therefore the interaction between ambas parts is recursiva.

40.2. Memory as soporte of the value

The Coherence Tensor not operates on a state bruto indiferenciado. Operates on a state that already ha sido fraccionado, cartografiado and reinyectado by the memory. Eso returns the calculation of the value mucho more barato and mucho more significativo. More barato because the topology memorial already ha organizado the information. More significativo because the fractions on the that is computed value already corresponden to charts reales of the whole.

40.3. Coherence as corrector of topology memorial

To the inversa, the coherence can actuar as corrector of the topology memorial. If ciertas Local charts produce value low of form recurrente, the architecture can aprender topologies distintas, mezclas local-globales distintas or sesgos distintos of the selector. Dicho of other manera: the memory organiza the value and the value reeduca the memory.

40.4. Consecuencia

The long memory deja of be a simple problema of conservation. Is returns a problema of conservation with structural health. Not basta with that the past persista. Must persistir of form that siga siendo valorable and operable by the Coherence Tensor.

41. Interaction between regime and

selector

41.1. The selector not is libre

Would be a error pensar that the selector decides charts without condicionamiento strong. In CTNet the selector is profundamente condicionado by regime. the regime not only entra as a vector extra; defines part of the Geometry of the selector.

41.2. Regime as bias of ecology

If the regime indicates that the system is in a modo of persistencia, a ecology of charts more concentrada can be razonable. If indicates that there is sorpresa high or disagreement high, the ecology should abrirse. That is, the regime not decides the chart final, but yes decides what General form can have the distribution on charts.

41.3. Separation strong

This interaction is precisamente it that prevents confundir selector with response. The selector not responde to the tarea as if fuese the output. Responde to the modo of computation that the regime ha establecido and to the value structural that memory and coherence han asignado to the background.

42. Interaction between order and

memory

42.1. Order as redistribución of mass memorial

When the order object segmental reordena branches or masas, not only changes the readout. Changes also what part of the state adquiere mayor mass contextual and, therefore, what part of the memory resulta more decisiva. Therefore the order not is a capa encima of memory: is a form of redistribuir its relevancia effective.

42.2. Stitching and retrospective

The Global stitching modifica retrospectivamente the reading of the memory local. A fraction memorial can parecer secundaria localmente and, however, ganar mass to the coserse globalmente with other. This is important because shows that the contextual value of a fraction memorial not is fijado of a vez by all in the momento of its construction local.

43. Interpretation of CTNet as

space of computation

43.1. Architecture against to modelo

CTNet must be understood less as a modelo singular and more as a space of computation. That space viene delimitado by its invariants and by the whole of cierres posibles on ellos. A architecture concreta can cerrar algunos axes and seguir perteneciendo to the familia; but cuanto more axes closure, more is acercará to a degeneration interna of the space.

43.2. Axes of the space

The axes main are:

• reversibilidad of the substrate, • topology of memory, • riqueza of the regime, • potencia of admissibility, • plurality of charts, • force of the Coherence Tensor, • interioridad of the order, • presencia of stitching local-global, • projection of output not soberana.

Each architecture particular can localizarse in that space according to what axes deje abiertos and cuáles closure.

44. Principios of design for futuros

desarrollos

44.1. Never collapse state and output

Cualquier development futuro of CTNet that vuelva to identificar state and output traicionaría the core of the architecture. The output must seguir siendo projection local of a background more rich.

44.2. Not convertir the memory in archivo puro

Is legítimo introduce buffers, caches or mecanismos auxiliares. Not is legítimo do of ellos the corazón of the memory of CTNet. The memory central must seguir siendo reentrant, parcial and topological.

44.3. Not reducir coherence to loss decorativa

This is a of the fronteras more important. The Coherence Tensor can expresarse as

loss, as drive or as modulator of reorganization. It that not must ocurrir is that pierda

all capacidad of alterar the system real.

44.4. Not usar order as simple encoding

If the dominio is not conmutativo, the order must seguir tratándose as object interno and not as encoding superficial of posiciones.

45. Consideraciones finales of

engineering theoretical

The engineering of CTNet not is resume in ‘‘add modules’’. Its dificultad real is in alinear topologies: topology of the substrate, topology of memory, topology of branches of order, topology of charts and topology of the value. The éxito of the architecture depende of that those topologies not compitan of form destructive, but that is acoplen in a common economy of the state.

Therefore the Coherence Tensor is tan central. Not because sea a term more, but because is the object that allows that all those topologies puedan compararse dentro of a same law of mass structural. Without it, the system conservaría plurality, but not sabría how much vale each fraction of that plurality. With it, the plurality deja of be multiplicidad blind and is converts in organization operativa of the value.

46. Conclusion suplementaria

The exposition long deja ver a point that in formulaciones breves can pass desapercibido: CTNet not only preserves structure; decides continuamente what part of that structure must have realidad operativa. That decision is reparte between regime, admissibility, selector and Coherence Tensor. The memory proporciona the atlas. the reversible substrate proporciona the background. The order proporciona the estratificación composicional. But is the coherence the that converts all that organization in economy dynamics effective.

In última instancia, the architecture can resumirse thus: a system distributed computes on a background persistent, not on a representation efímera; organiza the past in charts partial in vez of archivarlo linealmente; legalizes the presente before of leerlo; multiplica readings without perder the background; and converts value structural in mass real without separate analysis of dynamics. Ésa is the General form of the regime of computation CTNet.

Appendix OR. Recapitulación integral

module by module

OR.1. The substrate

The substrate makes posible a transition of the state without amputation generalizada of the historial. Its propiedad strong not is only that exista a function inversa, but that the cost of preserve structure sea menor that the of destruirla and reconstruirla from fuera. the reversible substrate, unido to multiradius mixture and coupling latent, establece the plane where all it others podrá operate.

OR.2. The memory

The memory not is archivo. Not equivale to a log of eventos nor to a consulta subsequent. Is a dispositivo of reinscripción of the past dentro of the presente. To the dividir the state in fractions, rotarlo, acoplarlo topologically and reintegrarlo by token, makes that the system can aumentar value recoverable without aumentar bruto of size.

OR.3. the regime

the regime not is a response semantic to ‘‘what tarea hago’’. Is a dispositivo that fixes the modo of transition. If the substrate is the campo and the memory is the atlas, the regime is the law local of conducción of that campo.

OR.4. The admissibility

The admissibility decides what part of the campo can seguir living without that the system between in mixture illegitimate, freezing or deriva unproductive. Introduces a semantic of legalidad interna of the calculation.

OR.5. The selector

The selector organiza the ecology of local readings. Not determines by yes only the verdad of a output. Determines from what charts must comparecer the output given the modo actual of the system.

OR.6. The readout

The readout not agota the work of the system; comparece after of it. Its function is dejar that the background persistent is vuelva legible without obligarlo to collapse in a single chart soberana.

OR.7. The Coherence Tensor

The Coherence Tensor une value and dynamics. Measures structural information, the converts in mass and makes that that mass reorganice the system. Therefore performs a role that no other piece can absorber.

OR.8. The order object

The order object prevents that the architecture trate the composition as conmutativa by defecto. Makes of the order a variable real of the calculation and not a simple etiqueta lateral.

OR.9. The stitching

The stitching local-global prevents the falsa alternativa between detail local and cohesión whole. Allows preserve ambos through a redistribución not destructive of masas and branches.

OR.10. The architecture as whole

The force of CTNet not is in a single of these parts. Is in that all operate on the same background and in that no intenta usurpar the function of the other. The substrate not decides charts. The selector not reemplaza regime. The memory not decides legalidad. The coherence not produces single the output. The order not sustituye to the substrate. Is precisamente this not sovereignty recíproca the that makes posible a regime of computation more rich.